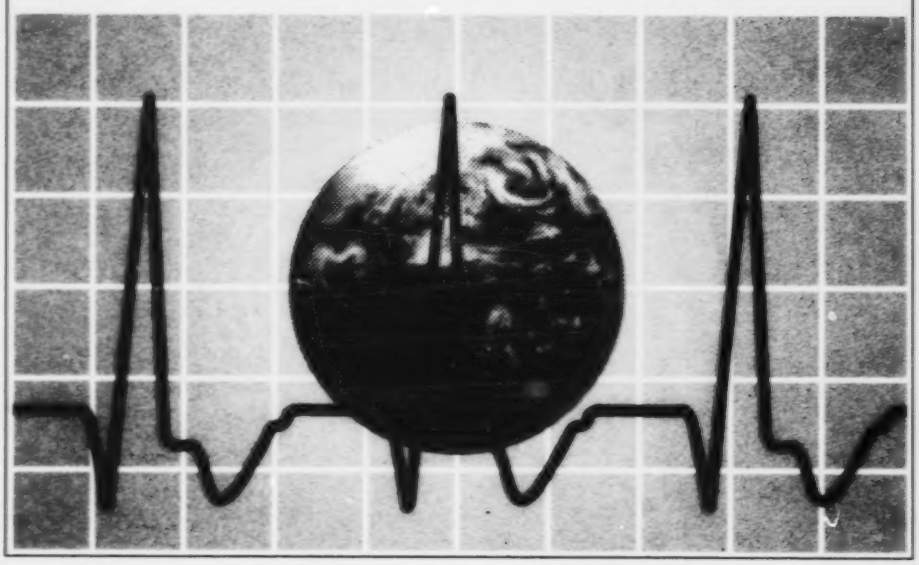
Environment Canada Environnement Canada

A State of the Environment Report

A Report on Canada's Progress Towards a National Set of Environmental Indicators



SOE Report No. 91-1

A State of the Environment Report

A Report on Canada's Progress Towards a National Set of Environmental Indicators

Indicators Task Force
Environment Canada

State of the Environment Reporting
Environment Canada

Également disponible en français sous le titre *Le point sur l'établissement d'un ensemble national d'indicateurs environnementaux au Canada*

Think Recycling!

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ERRATA

Page 28, Target (1) for CO should read: 8-hour maximum acceptable concentration in urban air is 13 parts per million.

Page 37, graph inset, legend order from top to bottom should read:

- **No treatment**
- **All treatments**
- **Tertiary**
- **Secondary**
- **Primary**

Page 50, para. 1, line 3, should read: ... betveen 1970 and 1987.

Page 53, graph legend should read:

blue = Strait of Georgia (Mandarte Island, B.C.)
green = Bay of Fundy (Manavagonish Island, N.B.)
gray = St. Lavrence Estuary (Île aux Pommes, Que.)

Page 54, graph legend for Furans, order from top to bottom should read:

- **Bay of Fundy (Manavagonish Island, N.B.)**
- **Strait of Georgia (Mandarte Island, B.C.)**

Page 84, graph legend, order from top to bottom should read:

- **Mining**
- **Manufacturing**
- **Canada Total**
- **Thermal Power**

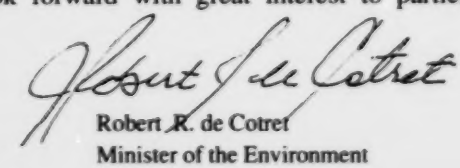
Preface

On December 11th, 1990, the government released **Canada's Green Plan**, this country's commitment "to secure for current and future generations a safe and healthy environment and a sound and prosperous economy." Among its specific goals, the government is committed to working towards environmentally responsible decision making at all levels of society. Everyone, individually and collectively, requires good, accessible environmental information on which to base those decisions. But, in today's world of information overload, the need is for authoritative, easy-to-use indicators by which to measure our environmental performance and progress towards sustainable development.

At one time, the conceptual and technical difficulties involved in constructing indicators made the whole idea seem analogous to a dark, bottomless pit. Nevertheless, the idea kept surfacing as decisions continued to be made using economic indicators, with little evident input from the environmental side. The notion of sustainable development, so effectively put before us by the World Commission on Environment and Development, brought with it a renewed imperative for more and better environmental information. The G-7's call for environmental indicators at the Paris Economic Summit in July 1989 provided further impetus. Today, concerted efforts are being devoted to the development of environmental indicators.

In **Canada's Green Plan**, the federal government made a commitment to develop, by mid-1991, a preliminary national set of environmental indicators and to initiate stakeholder consultations. This report is an early demonstration of that commitment. The government is further committed to developing and releasing, on a regular basis, a comprehensive set of environmental indicators by 1993. Our ultimate goal is to develop a comprehensive state of the environment index equivalent to the GNP.

This report documents the current systematic efforts to develop a national set of environmental indicators that, taken together, give a profile of the state of Canada's environment and indicate trends towards sustainable development. The set is obviously a first step. The measures need to be critically evaluated and tested for their relevance to decision making in a sustainable development context, and they need to be augmented and refined through further research and development. It will take some years of trial and error before a definitive set of environmental indicators will be agreed upon, accepted, and used. Nonetheless, the first crucial step has been taken to move us from the conceptual to the practical. With this progress report, a concrete series of indicators has been placed on the table for all to examine. They are designed to provide the basis for further discussion that will move us towards our goal of providing timely and understandable environmental information. This report's fundamental purpose is to stimulate constructive dialogue. I look forward with great interest to participating in these consultations.



Robert R. de Cotret
Minister of the Environment

Executive Summary

Environmental indicators are important tools for translating quantities of environmental data into succinct information that can be readily understood and used by decision makers and the general public. For years we have used economic indicators to measure how well the economy is performing, but we have few indicators to tell us about the state of our environment. The development of environmental indicators is a key factor in enabling us to measure progress towards the goals of sustainable development.

The first step has been taken. The Organisation for Economic Co-operation and Development (OECD) is currently leading an international initiative to develop a series of indicators that will measure the environmental performance of countries.

Canada has responded to the challenge on a number of fronts. In particular, the federal government has embarked on a long-term project to develop a national set of environmental indicators. A framework for indicator development has been established, surveys of opinion leaders and potential users have been conducted, criteria for indicator selection have been defined, and an Indicators Task Force in Environment Canada has been created to lead and coordinate the National Environmental Indicators Project, which involves, at this stage, numerous other federal departments.

Through consultation with data holders and specialists, a preliminary set of environmental indicators, based on existing information and monitoring, has been identified. The results — 43 indicators in 18 "issue" areas — are presented in Annex 1 of the report. They will be the basis for further, more widely based consultations to improve, augment, and refine this initial set.

Much research and development work needs to be done. It took more than 30 years to develop and refine economic indicators to their present degree of sophistication. Similarly, it is realistic to expect years of development work for environmental indicators to evolve to the same level. The aim is that, ultimately, environmental indicators will be the tools by which environmental performance can be measured and compared with the goals of sustainable development.

Acknowledgements

The preliminary set of indicators presented in this report is the product of the National Environmental Indicators Project, a federal initiative led by Environment Canada. This, the first phase of the project, was conducted under the direction of Leslie Whitby, director, and Paul Rump, acting director, State of the Environment Reporting, Environment Canada.

Environment Canada created an Indicators Task Force to lead and coordinate the development of a preliminary national set of environmental indicators. Task force members are:

Anne Kerr, *Head*	Dana Vindasius
Terence McRae	Harry Hirvonen
Lucie Métras	Kevin Brady
Ilze Reiss	Greg Shaw

Bruce Mitchell is Statistics Canada's advisor to the Task Force.

Many others, in federal departments and agencies with responsibility for environmental quality and natural resource management in Canada, are partners in the project, contributing their data, expertise, and commitment to indicator development. They are listed below:

Agriculture Canada: L. Benzing-Purdie, A. Boostma, M. Brklacich, D. Coote, J. Dumanski, A. Eagle, P. Fehr.

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A number of people provided valuable services to this progress report; their efforts were much appreciated:

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Introduction

Of the problems facing people and governments in the final years of the 20th century, among the most subtle, pervasive, and challenging are those related to the environment. The way we deal with the environment — whether in business, government, or the home — must now meet new and demanding ethical and scientific standards in Canada, as elsewhere.

We have become accustomed to using economic indicators to help assess the state of our economy. Such indicators as interest rates continue to influence major decisions made by individuals, corporations, institutions, and governments. By contrast, there are few systematically reported indicators to assist us in evaluating the environment.

We cannot look to traditional economic indicators in assessing the importance of the environment to our individual and collective future. They are not designed to reflect such factors as the cost to wildlife and habitat that results from an oil spill, or the consequences of acid rain as it affects the livelihood and even the well-being of Canadians. As a result, reliance on economic indicators can distort the environmental reality in which we live. Decision making based on economic indicators but isolated from environmental factors will not move us towards the goals of sustainable development.

Despite widespread agreement on the need for environmental indicators, the process involved in developing them is long and complex, one that will challenge our ingenuity and knowledge for many years to come. What is most important is not that the search for indicators is complete — that will take some time yet — but that the process has begun, that it involves many agencies and individuals, and that progress is being made.

This report presents a brief overview — a snapshot, as it were — of efforts now under way to develop consistent, reliable indicators to measure the quality of our environment, the stresses placed on it, and the steps taken to prevent or reduce those stresses.

Obtaining Better Environmental Information

Canadians, in opinion polls over the past few years, have consistently ranked the environment at or near the top of their list of concerns. It is widely recognized that we must be prepared to make changes to traditional attitudes and behaviour if we are to improve environmental quality and make progress towards sustainable development. It is our day-to-day behaviour, and the decisions that underlie it, that are the litmus test of our intentions. The countless choices made by individual Canadians, acting alone or in concert, affect the environment and shape the economy. The impact of human beings on the environment is determined by the energy, materials, and waste that result from the way people maintain their homes, travel to work, prepare meals, and enjoy leisure time; by the way business is carried on; and by the longer-term investment plans of government and the business sector.

Canadians want more and better environmental information — easily understood, readily available, and widely disseminated — on which to base these changes. Anecdotal evidence of environmental degradation, however persuasive, is simply not good enough to meet our needs. We must have reliable information about the current state of the environment, the factors that endanger it, and the steps that must be taken, either to heal damage or to prevent it from occurring in the first place. We can then make appropriate future commitments of time, energy, and resources to meet the environmental challenges we face.

State of the Environment Reporting

State of the Environment (SOE) reporting describes, analyzes, and presents scientifically based information on environmental conditions, trends, and their significance. It looks at the effects of human activities on the environment, as well as their implications for human health, economic well-being, and the state of ecosystems.

In 1988, the Government of Canada established an SOE reporting program under the leadership of Environment Canada and Statistics Canada. Environment Canada's newly created SOE Reporting Branch was given the task of leading and managing the SOE reporting program of Environment Canada.

A reorganization within Environment Canada in 1990 further recognized the importance of the branch as it prepares to meet increased demands that will result from Canada's new environmental agenda. "The Green Plan," recently presented by the Government of Canada, includes a commitment to deliver timely, understandable environmental information through a number of tools, including environmental indicators.

Environmental Indicators

SOE reporting is only as useful as the information on which it is based. Therefore, the measuring devices used to evaluate problems, their causes, and the steps taken to overcome them are a fundamentally important part of the process. They are comparable to yardsticks developed in other fields over the years: temperature, humidity, and wind speed offer a snapshot of the weather; body temperature is an important clue to overall health; the unemployment rate, the consumer price index, and the Gross Domestic Product (GDP) give some idea of the condition of the economy. In the same way that weather forecasters predict storms, doctors prescribe medicine, and businesses make plans for the future on the basis of those kinds of information, consistent and informative environmental indicators will help governments, businesses, and individual citizens to identify environmental problems and to act on them.

However, the interpretation of masses of environmental data collected by scientists and researchers presents a daunting task to the average person. Furthermore, cause and effect are not easily determined in the dynamic, complex web that is the environment. Environmental indicators need to be selected from this information and presented to decision makers and to the general public in ways that are relevant to them and can be readily understood.

Environmental indicators can provide early warning of potential environmental problems and signify our ability to manage and resolve these problems. They can be used to monitor trends on the extent to which human activity is causing environmental stress.

Once indicators have identified areas or elements of the environment that are under stress, management of problems can be measured in relation to identified goals and targets. Our success or lack of it in reaching targets can tell us whether we are closer to attaining the goals of sustainable development.

International Context

There is widespread recognition of the need for environmental indicators. At the 1989 G-7 Economic Summit in Paris, Prime Minister Mulroney called for:

> new environmental indicators that will allow governments, business and private citizens to measure the state of the environment and the relationship of environmental indicators to economic development.

Participants in the meeting acknowledged that their economic decisions have significant environmental implications. As a result, G-7 asked the Organisation for Economic Co-operation and Development (OECD) to develop environmental indicators in the context of its work on integrating environmental and economic decision making. An international effort is under way in the OECD to develop three types of indicators:

- state of the environment (SOE) indicators to reflect the quality of the environment, the stresses on it, and the management responses to both quality and stress;
- indicators of the impact on the environment and the environmental efficiency of such key sectors as agriculture, energy, transportation, and industry, and the degree to which environmental concerns are being integrated into the policies in these sectors;
- indicators that integrate economic and environmental elements so that, for example, the value of natural resources and the costs of pollution are reflected in national accounts.

Canada, as a member of both G-7 and the OECD, has embarked on a long-term program to address these three areas of indicator development.

Canada's Initiatives in Developing Indicators

Although work on development of indicators had begun in the 1970s and continued intermittently — some indicators were introduced in the 1986 publications, *State of the Environment Report for Canada* and *Human Activity and the Environment* — the request from the Economic Summit gave impetus to the process.

Today, a number of groups and organizations are involved in efforts to establish indicators. Among those that have a particular interest in indicator development: the National Round Table on Environment and Economy; various provincial Round Tables on Environment and Economy; the Canadian Environmental Advisory Council; and Environment Canada.

In the aftermath of the report of the World Commission on Environment and Development, *Our Common Future*, the **National Round Table on Environment and Economy** was established by the Government of Canada to consider and give advice on major environment–economy-related issues. It includes representatives of business, government, labour, academia, and non-government environmental organizations.

As part of its commitment to sustainable development, the National Round Table has formed a sub-group to develop indicators, using energy as a prototype. The purpose is to give decision makers specific guides to making choices consistent with sustainable development and to enable them to evaluate their progress in reaching that goal.

There are also **provincial Round Tables on Environment and Economy**, with mandates analogous to the national body. Some of them have also begun developing environmental indicators; in Ontario, for example, the Round Table is working on measures in such sectors as energy and minerals, agriculture and food, transportation, manufacturing, and urban development and commerce.

The **Canadian Environmental Advisory Council**, an independent body of community leaders that advises the Minister of the Environment on relevant issues, has been investigating the development of indicators. With selected experts and decision makers, the Council has been exploring links between economic, ecological, social, and decision theories as they might apply to developing indicators for sustainable development.

In 1988, the Public Advisory Committee for Canada's State of the Environment Reporting Program suggested that an effort be made to explore the concept of environmental indicators. By early 1989, **Environment Canada** had conducted a review of existing literature on the subject. That was followed by an inventory of federal government researchers and research related to environmental indicators, a necessary step in building a network of scientists interested in the field. Results of pilot studies to develop the concept of indicators have been produced as internal SOE technical reports (see References).

Since then, Environment Canada has established a systematic approach to developing a national set of environmental indicators. It has, for example, dedicated funds and personnel to the **Indicators Task Force**, to lead the federal effort in indicator development. This leadership role also includes continuing liaison and cooperation with the various other indicator initiatives under way in Canada.

Canada's National Environmental Indicators Project

The objective of the federal government's National Environmental Indicators Project is to develop scientifically credible, understandable indicators, relevant to decision makers and the public, and to report regularly on them. This is a long-term process, starting with indicators based on existing information. A preliminary set of indicators will be available for use by Canadians in the short term. In the longer term, a more complete, and perhaps more sophisticated, series of broad environmental indices can be developed, drawing data from both existing monitoring programs and those that will be specially designed for state of the environment reporting.

In February 1990, in response to the high priority Environment Canada places on indicator development, the Indicators Task Force was established to lead the development of an initial set of national environmental indicators. It comprises specialists from Environment Canada working with an advisor from Statistics Canada. The Task Force drew from previous studies and workshops to devise a strategy and approach by which to develop this set.

The Process

A number of steps helped to guide the process of selecting environmental indicators:

1) identify societal goals to which the indicators relate;

2) devise a framework within which they operate;

3) identify selection criteria by which to judge potential indicators;

4) consult with data holders, experts, and potential users; and

5) verify that the indicators communicate the message effectively to the intended audiences.

Here, briefly is a description of these five steps:

1) **Societal goals**: Sustainable development as a principal societal objective has three broad environment-related goals: to assure the viability of the ecosystem; the protection, maintenance, and sustainability of natural resources; and the protection and enhancement of human health and well-being. They provide the overall context for the identification of useful environmental indicators.

2) **Conceptual framework**: A framework is required to set the bounds and structure of the investigation. To ensure the technical feasibility and orderly development of indicators, Environment Canada and Statistics Canada worked with technical experts to identify an initial framework and a selection methodology for developing a national set of environmental indicators (VHB Research and Consulting Inc. 1989). These experts considered, but rejected, a single-number index to represent the state of Canada's environment; constructing such an index was deemed too complex to meet the goals set for indicator development and is not feasible in the short term, or possibly even in the long term.

In addition to the technical perspective in setting that framework, it was necessary to consider the needs of potential indicator users. Therefore, 51 community leaders across Canada — among them, environmentalists, health professionals, representatives of native groups, industrialists, academics, and public servants from the federal and provincial governments — were asked for their views on developing environmental indicators that they would find useful in making decisions (Western Environmental and Social Trends 1990).

The purpose was not to poll opinion, but to identify what people expected and wanted. The consultation showed that people want indicators that are: related to those things they do or they value; credible and widely accepted; reported simply; responsive to short-term change; sensitive to regional variations; and flexible enough to incorporate new scientific information and changing public perceptions. Participants also urged that indicators be linked to each other and, in particular, that environmental and health indicators be linked with those related to the economy.

Potential users and indicator specialists had the opportunity to meet, and exchange ideas and information, in a workshop held in the fall of 1989 at Vaudreuil, Quebec. They agreed that indicators would have to be simple, based on the best available science, tailored to the needs of users, effectively communicated, and reported frequently. Following the workshop, Environment Canada and Health and Welfare Canada, working with a small steering committee that includes non-government health professionals among others, began a feasibility study to explore expanding the environment–economy link to include health and other concerns.

The views that emerged from the various meetings and discussions were considered by the Indicators Task Force in further refining the framework for indicator development. A matrix was developed to reflect the proposed framework. This matrix and associated elements are shown in Annex 2.

Three broad categories of the matrix correspond to the environment-related goals for sustainable development: environmental components, environment-related human health, and natural economic resources.

In order to identify the types of indicators required under each category, the following three questions were asked:

- What is happening to the state of the environment and our natural resource assets? (What are the changes and trends?);
- Why is it happening? (causes and stresses);
- What are we doing about it? (management responses).

To answer these questions, and in keeping with the OECD approach, the types of indicators reflect the *condition* of the environment, the *stresses* imposed on the environment by human activity, and the way that we *manage* in response to those stresses.

The matrix is a conceptual tool that helps ensure indicators are identified in a systematic and comprehensive way. In practice, it is difficult to adhere too rigidly to the matrix, because the environment is a complex web of interconnected systems, and direct cause-and-effect can seldom be established. Using water as an example: water is clearly a basic environmental component. However, because clean water is also a fundamental necessity for human survival, it belongs just as clearly in the part of the matrix devoted to human health.

As a result of these complexities, the preliminary indicators package (Annex 1) deals with stresses such as acid rain or activities such as the disposal of solid wastes in a non-causal way, whereas human health-related indicators are integrated into the environmental components.

3) **Selection criteria**: As part of the process, the basic selection criteria that a national environmental indicator should meet were identified.

To be considered for inclusion in the list of national indicator candidates, a measure should: be scientifically valid; be supported by sufficient data in order to show trends over time; be responsive to changes in the environment; be representative; be understandable; be relevant to stated goals, objectives, and issues of concern; and (ideally) have a target or threshold

level against which to compare it. Indicators should be either national in scope or applicable to regional environmental issues of national significance.

As a general observation, the process of identifying sets of representative indicators to monitor trends, stress, and management responses will, of necessity, entail value judgements. These include selecting the few phenomena, among a range of possibilities, that best represent and relate to the objectives of the project; selecting trends deemed crucial; and determining the significance of levels and rates of change.

There are likely to be disagreements about the choice of indicators. Differing value judgements on significance may reflect the differing priority given to an environmental issue in various parts of the country. In an extreme case, a particular change that is seen as acceptable according to one person's standards can represent deterioration by another.

4) **Consultations**: After an extensive review of both the indicator literature and various national and international indicator initiatives, the Task Force produced discussion papers on potential indicators. These formed the basis for Task Force consultations with data experts and subject-area specialists, primarily in the federal departments of Agriculture; Energy, Mines and Resources; Fisheries and Oceans; Forestry; Health and Welfare; Statistics; various units within Environment Canada; and in the National Museum of Natural Sciences. A limited number of agencies outside government and in provincial governments were also contacted. All these discussions were designed to evaluate the validity, availability, significance, and relevance to users of these and other possible indicators.

The preliminary environmental indicators set out in Annex 1 of this report will serve as the basis for a wider range of consultations in the next phase of indicator development. In continuing to provide leadership in that task, Environment Canada will expand its consultations with those who hold information and will explore with them the potential for making better use of existing data and data systems, as well as dealing with the need for new data. Groups or organizations, including those not already involved, may wish to augment current data, to their own advantage and for the benefit of indicator development.

5) **Validation and effective communications**: In the future, activities will include validating and evaluating the effectiveness of the indicators and how they are communicated to intended audiences.

Challenges to be Met

It appears a deceptively simple matter to devise an environmental indicator: the presence or absence of a toxic substance; an increase or decrease in a wildlife population; the frequency of environmental accidents. In practice, it is a complicated business. For example:

- information exists for some parts of the country, or for some components of the environment, and not others;
- data exist for limited periods of time, thus precluding analysis of environmental trends;
- in many instances, measurements or definitions are not standardized, so that one region cannot be compared with another; nor can data be compared from year to year;
- new techniques and advances in methodology compound problems caused by the lack of standardized measurement;
- in many cases, the data are in raw form — they have not been analyzed or otherwise processed into meaningful environmental information that can serve as the basis for a national or a significant regional assessment. In addition, there are severe methodological difficulties in aggregating some complex data sets into a representative national overview; and
- there is inadequate auditing of the quality and relevance of the data collected.

Some examples illustrate these concerns.

- It is possible to obtain a national picture of concentrations of common air pollutants in urban areas because they are being monitored across the country and information is fed into a national database. On the other hand, data on beach closures, which can indicate the risk to health from water pollution, are collected locally. There is no national collection system for such data.
- For an issue such as depletion of the stratospheric ozone layer, one or two indicators — stratospheric ozone levels and global consumption of ozone-depleting chemicals — can provide a sense of what is happening. This is in contrast to determining accurately the environmental quality of our marine resources, which requires a diverse set of measures.
- Closure of areas to shellfish harvesting can result from, for example, high fecal bacteria counts in the

water, which in turn may indicate a sewage problem. But that does not indicate whether toxic contaminants are present. However, concentrations of toxic chemicals in seabird eggs have proven to be a useful indicator of contaminant levels in the marine environment. Thus, a combination of measures is needed to give a more complete picture of marine environmental quality.

- Given the tremendous natural variability of surface waters in Canada, it is difficult to construct a national set of water quality indicators. Developing regional profiles based on composite water quality data may yield more usable indicators in the short term.
- Groundwater quality is a special concern in specific regions of the country (for example, where drinking water comes entirely from groundwater sources), but systematically reported data are currently unavailable to support indicator development.
- Agriculturalists agree that change in the organic content of the soil is a useful indicator of its quality, but readily accessible data are not available from which to form a national picture. Indeed, because soils and cropping practices — two key factors affecting organic soil content — are widely variable across Canada, it may be more practical to take a regional approach to indicator development of soil quality.
- Some experts argue that a commonly used environmental indicator, nitrogenous fertilizer applied to arable land, is misleading. More appropriate indicators, such as fertilizer use per unit of crop production, or fertilizer residual after crop uptake, are more difficult to construct. Each presents a challenge to indicator development in the future.

A Preliminary List of National Environmental Indicators

In view of the difficulties, a measure, or any set of measures, must be assessed carefully before being accepted as an indicator. Because of the technical and jurisdictional complexities of developing such measures for Canada's environment, indicator development will be a lengthy process. However, a list of possible candidates has been developed.

The following preliminary list of indicators, developed through the National Environmental Indicators Project, is the result of the various consultations, discussions, and review. As explained earlier, the underlying matrix of the framework is only partially in evidence. Rather, based on consultations with potential users, the indicators are presented in more of an "issues" context. The category is shown first, followed by the "issue," and then the indicators.

ATMOSPHERE

Climate Change

- Canadian energy-related emissions of carbon dioxide (CO_2)
- Atmospheric concentrations of CO_2
- Global air temperature

Stratospheric Ozone Depletion

- Canadian production and importation of ozone-depleting chemicals
- Stratospheric ozone levels

Radiation Exposure

- Levels of radioactivity in the air

Acid Rain

- Sulphur dioxide (SO_2) and nitrogen oxides (NO_x) emissions

Outdoor Urban Air Quality

– Common Air Pollutants

- Nitrogen dioxide (NO_2) and carbon monoxide (CO): Levels in urban air and emissions
- SO_2 and total suspended particulates (TSP): Levels in urban air and emissions
- Ground-level ozone concentrations

– Air Toxics

- Lead concentrations in urban air

WATER

Freshwater Quality

- Population served by treated water supply
- Municipal discharges to fresh water: BOD (biochemical oxygen demand), TSS (total suspended solids), and phosphorus
- Pulp and paper mill discharges to fresh water: TSS and BOD
- Discharges of regulated substances by petroleum refineries to water
- Concentrations of phosphorus and nitrogen in water

- Maximum observed concentrations of pesticides in water: 2,4-D, atrazine, and lindane

Toxic Contaminants in the Freshwater Ecosystem
- Contaminant levels in Herring Gull eggs in the Great Lakes Basin: PCBs (polychlorinated biphenyls) and DDE (dichlorodiphenyldichloroethylene)
- Contaminant levels in Lake Trout, a sport fish from the Great Lakes Basin: PCBs and DDT (dichlorodiphenyltrichloroethane)

Marine Environmental Quality
- Municipal discharges to coastal waters: TSS and BOD
- Pulp and paper mill discharges to coastal waters: TSS and BOD
- Volume of significant marine spills
- Area closed to shellfish harvesting
- Contaminant levels in seabird eggs: PCBs
- Contaminant levels in seabird eggs: Dioxins and furans

BIOTA (LIVING ORGANISMS)

Biological Diversity at Risk
- Wildlife species at risk

State of Wildlife
- Levels of migratory game bird populations

LAND

Protected Areas
- Land under protected status

Urbanization
- Rural to urban land conversion

Solid Waste Management
- Municipal solid waste disposal trends

NATURAL ECONOMIC RESOURCES

Forestry
- Regeneration success versus total forest area harvested

Agriculture
- Changes in agricultural land use
- Amount of chemical fertilizer used and its associated nutrient content
- Agricultural pesticide application on cultivated land

Fisheries
- Total commercial fish catches in Canadian waters off the Atlantic coast
- Commercial fish harvest in the Great Lakes

Water Use
- Total water withdrawal compared with growth in Gross Domestic Product (GDP)
- Rates of water withdrawal and consumption by key economic sectors
- Rates of water recirculation by key industrial sectors
- Daily household water use per capita

Energy
- Total per capita primary energy use
- Emissions of CO_2 per unit of energy consumed
- Fossil fuel intensity of primary energy demand

This preliminary set of environmental indicators is presented in greater detail in Annex 1. Undoubtedly imperfect and incomplete, it nonetheless shows how the search has moved from the purely theoretical to concrete efforts to identify, describe, and assess specific indicators that might prove useful.

The Future

With work on the first stage of indicator definition now complete, it is possible to begin mapping out the next steps. The immediate goal will be to refine, augment, and improve the initial set of indicator candidates presented in this document and to use this report as the basis for further consultations.

If we are to have an accurate and comprehensive picture of the state of Canada's environment, we will need to improve the quality and timeliness of data, expand the scope and efficiency of data-gathering systems, and standardize information management systems.

At present, many of the data on which this initial set of indicators is based are from federal sources. In the next phase of indicator development, it will be important to include more provincial, regional, and municipal data. Clearly, differences in methods and standards will

emerge, and attempts will have to be made to rationalize them.

Many data are not available in an accessible form; it will be important to determine what can be made usable in supporting indicators and, over the next 12 to 18 months, expand consultations to include other stakeholders such as businesses and universities who can contribute to, and benefit from, indicator development.

A number of initiatives are already under way. They range from a nation-wide survey of individual consumer habits related to the environment, to indicators being developed in Canada's regions, to the strategies particular sectors are using in developing indicators. Among current projects:

Households, Municipalities, and Businesses: At the national level, Statistics Canada is moving to expand existing surveys of households, institutions, and industries in order to gather environment-related information. Initiatives include: a pilot survey of households and the environment; a survey of waste management firms; a survey of pollution abatement and pollution-control expenditures; and a study of garbage collection, disposal, and recycling practices in certain Canadian municipalities.

Such information might support development of a Canadian Household Environmental Index, which would offer householders a way of measuring energy use, water consumption, solid waste production, and utilization of recyclable materials. If indicators were established for these activities, Canadians would be able to monitor, evaluate, and change their activities in keeping with environmental goals.

Packaging: The National Task Force on Packaging, a group established by the Canadian Council of Ministers of the Environment, has developed national policies on packaging. The ultimate goal is to cut packaging by 50 per cent by the year 2000. A nationally coordinated data collection program should yield indicators by which progress towards the target could be measured.

National Air Quality Index: In 1991, Environment Canada's Environmental Protection Directorate will publish a National Air Quality Index, which will summarize information on common air pollutants. In addition, monitoring enforcement of new regulations for toxic substances under the Canadian Environmental Protection Act should yield data to support new indicators.

Agriculture: In its 1990 report to ministers of agriculture, the Federal–Provincial Agriculture Committee on Environmental Sustainability recommended that indicators be developed to monitor and assess the quality of natural resources and the environment, as those relate to agriculture. It will mean developing more comprehensive databases on agricultural resources and identifying physical and economic indicators appropriate to the agricultural sector.

National Parks and National Historic Sites: Work is under way, through State of the Parks Reporting, to develop and apply specific indicators relating to ecological integrity and commemorative integrity for Canada's National Parks and National Historic Sites.

Birds: Environment Canada's Canadian Wildlife Service is preparing a status report on the wide variety of songbirds in Canada, using the Breeding Bird Survey data collected over the past 30 years, as well as other sources. The interpretation of these data, for example impacts of development on songbirds, should support a useful indicator.

Automobiles: Environment Canada is also exploring the various environmental impacts of a car throughout its life cycle, from which relevant data might eventually translate into indicators.

Ecosystem Health: Under Environment Canada's State of the Environment Reporting program, a research project dealing with regional ecological indicators has been initiated. In the first stage, it will assess existing and potential stresses on selected ecological regions ("ecozones") in Canada. A framework for identifying indicators that would be appropriate to each ecozone is currently being developed.

Regional Initiatives: In Canada, there are regional areas of particular environmental significance, among them three for which indicators are being developed: the Arctic, the St. Lawrence River, and the Great Lakes.

- **The Arctic:** Indian and Northern Affairs Canada has developed a 5-year Research and Monitoring Plan for Contaminants in Northern Ecosystems and Northern Diets. Already under way are programs that monitor contaminant deposition in snow and ice; contaminant trends in such aquatic biota as ringed seals, polar bears, beluga whales, whitefish, lake trout, geese, and ducks. In addition, a feasibility study has been conducted to measure and compare trends of contaminants in people living in the Northwest Territories with those living in the Great Lakes and Quebec.

- **The St. Lawrence River:** The St. Lawrence Action Plan, a federal program, outlines a strategy for cleaning up, protecting, restoring, and preserving the St. Lawrence River. Part of the plan involves developing two sets of indicators: one to monitor progress in meeting the objectives of the plan itself, and the other to monitor the evolving environment of the St. Lawrence River. It is expected that technical reports on the two sets of indicators will be available this spring.
- **The Great Lakes:** The Great Lakes International Surveillance Plan (GLISP) provides data to assess emerging trends and long-term problems in the quality of the lakes. The Pollution Prevention Initiative for the Great Lakes Basin, a joint project of Environment Canada and the U.S. Environmental Protection Agency, is a support for GLISP; it will concentrate on reducing persistent toxic compounds at their source and will identify indicators to track the progress of pollution-prevention initiatives.

Conclusion

Clearly, the determination to establish reliable indicators to assess the state of the environment and assess progress towards sustainable development implies a considerable commitment of resources, expertise, and time. It is worth remembering that it took more than half a century to establish the kinds of economic indicators that we now take for granted as we make our day-to-day individual and collective decisions.

The most important overall result of the past 18 months is that a commitment has been made publicly, at the highest level, to the development of environmental indicators. The policy of the Government of Canada is to report regularly to Canadians, by the end of 1993, on trends in the environment, based on the indicators now being developed.

The goal is to ensure that, ultimately, environmental indicators will be used as widely — and be as relied on — as economic indicators are today; that they will influence decision making at all levels, as Canadians go about their daily lives.

References

Bird, P.M., and D.J. Rapport. 1986. State of the Environment Report for Canada. Environment Canada. Ottawa.

Division des stratégies et méthodes scientifiques. 1989. Atlas sur l'état de l'environnement du fleuve Saint-Laurent. RÉE rapport technique n° 12. Division des stratégies et méthodes scientifiques, Direction de l'état de l'environnement, Environnement Canada. *Unpublished.*

Division des stratégies et méthodes scientifiques. 1989. Rapport sur les processus naturels et les activités humaines et leurs effets sur l'environnement du fleuve Saint-Laurent. RÉE rapport technique n° 13. Division des stratégies et méthodes scientifiques, Direction de l'état de l'environnement, Environnement Canada. *Unpublished.*

Division des stratégies et méthodes scientifiques. 1989. Évaluation et cartes synthèses de l'atlas sur l'état de l'environnement du fleuve Saint-Laurent. RÉE rapport technique n° 14. Division des stratégies et méthodes scientifiques, Direction de l'état de l'environnement, Environnement Canada. *Unpublished.*

Gélinas, R., and J. Slaats. 1989. Selecting Indicators for State of the Environment Reporting. SOE Technical Report Series No. 8. Strategies and Scientific Methods, State of the Environment Reporting Branch, Environment Canada. *Unpublished.*

Keddy, C.J., and T. McRae. 1989. Environmental Databases for State of the Environment Reporting: Conservation and Protection Headquarters. SOE Technical Report Series No. 9. Strategies and Scientific Methods, State of the Environment Reporting Branch, Environment Canada. *Unpublished.*

McRae, T. 1990. Environmental Databases for State of the Environment Reporting: Atmospheric Environment Service, Canadian Parks Service, Corporate Policy Group, Environment Canada Regional Offices. SOE Technical Report Series No. 16. Strategies and Scientific Methods, State of the Environment Reporting Branch, Environment Canada. *Unpublished.*

Sheehy, G. 1989. Environmental Indicator Research: A Literature Review for the State of the Environment Reporting. SOE Technical Report Series No. 7. Strategies and Scientific Methods, State of the Environment Reporting Branch, Environment Canada. *Unpublished.*

Sheehy, G. 1989. The Use of Indicators to Show the State and Recent Trends in Sustainable Development. SOE Technical Report Series No. 10. Strategies and Scientific Methods, State of the Environment Reporting Branch, Environment Canada. *Unpublished.*

Sheehy, G. 1989. The Use of Indicators to Show the State and Recent Trends in Sustainable Development: A Forestry Pilot Study. SOE Technical Report Series No. 11. Strategies and Scientific Methods, State of the Environment Reporting Branch, Environment Canada. *Unpublished.*

Sheehy, G. 1990. Developing a Federal Environmental Indicator Research Network. SOE Technical Report Series No. 18. Strategies and Scientific Methods, State of the Environment Reporting Branch, Environment Canada. *Unpublished.*

Statistics Canada. 1986. Human Activity and the Environment: A Statistical Compendium. Analytical Studies Branch, Statistics Canada. Ottawa.

VHB Research and Consulting Inc. 1989. Indicators and Indices of the State of the Environment. SOE Technical Report Series No. 15. Strategies and Scientific Methods, State of the Environment Reporting Branch, Environment Canada. *Unpublished.*

Western Environmental and Social Trends. 1990. Environmental Indicators: Opinions of Potential Users. SOE Technical Report Series No. 17. State of the Environment Reporting, Environment Canada. *Unpublished.*

Western Environmental and Social Trends (eds.). 1990. *(Draft)* Indicators for a Sustainable Society: Workshop Proceedings. November 13–15, 1989, Vaudreuil, Quebec. Prepared for Environment Canada and Health and Welfare Canada.

World Commission on Environment and Development. 1987. Our Common Future. Oxford University Press. New York.

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Atmosphere

Climate Change

The atmosphere's role as a global regulator of temperature and climate is essential to life on Earth. Naturally occurring atmospheric gases such as carbon dioxide (CO_2), methane, and nitrous oxide, which are popularly known as "greenhouse gases," collectively behave as an insulating blanket around the planet. Synthetic chlorofluorocarbons (CFCs) are also important greenhouse gases. Their effect on incoming solar radiation, which fuels Earth's climate system, is minimal. However, their combined influence on the longwave radiation emitted from the Earth's surface and lower atmosphere towards space is substantial. By absorbing and returning much of this outgoing radiation, they effectively trap heat within the lower atmosphere. This "greenhouse effect" is naturally occurring and essential to the maintenance of life on Earth. Without it, the Earth's surface would be some 30°C colder. Changes in the concentrations of these greenhouse gases may result in global climate change (Hilborn and Still 1990).

Earth's climate is known to have changed radically throughout history. The first significant presence of ice occurred several million years ago. Since then, there have been recurring periods of glaciation, in particular in the northern hemisphere, the most recent of which peaked about 18 000 years ago. Abrupt climate change has been associated with historical transitions in plant and animal life, such as the extinction of dinosaurs. However, these changes have never exceeded the limits beyond which life could no longer adapt and survive (Hilborn and Still 1990).

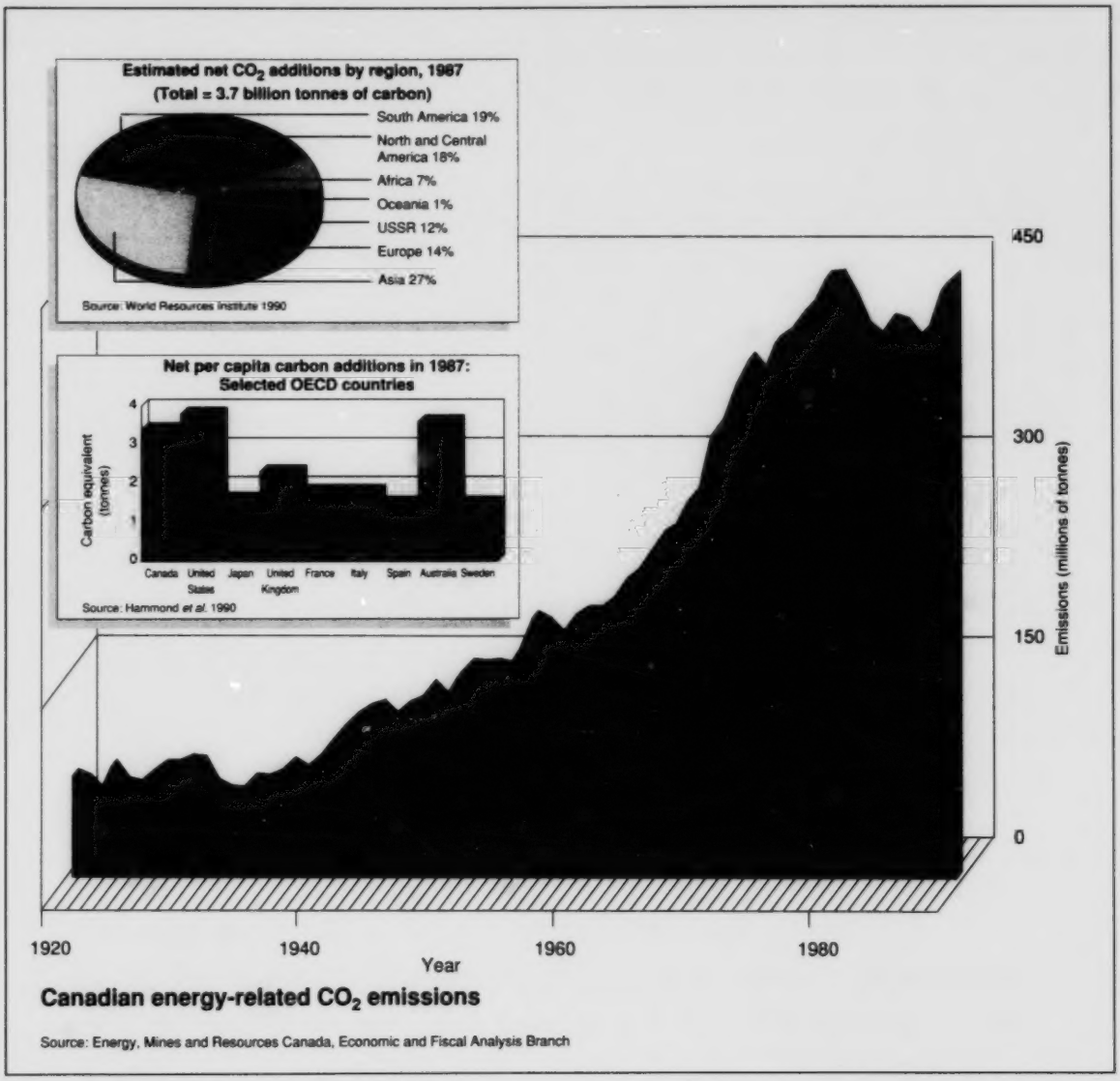
Climate change associated with human activities has recently been added to the short list of global environmental issues. This is because atmospheric concentrations of gases such as CO_2, the most important of the greenhouse gases, are increasing.

The indicators for climate change presented here are:

* Canadian energy-related emissions of carbon dioxide (CO_2)
* Atmospheric concentrations of CO_2
* Global air temperature

Indicator
Canadian energy-related emissions of carbon dioxide (CO_2)

Target Stabilization of CO_2 emissions at 1990 levels by the year 2000



Canadian energy-related CO_2 emissions

Source: Energy, Mines and Resources Canada, Economic and Fiscal Analysis Branch

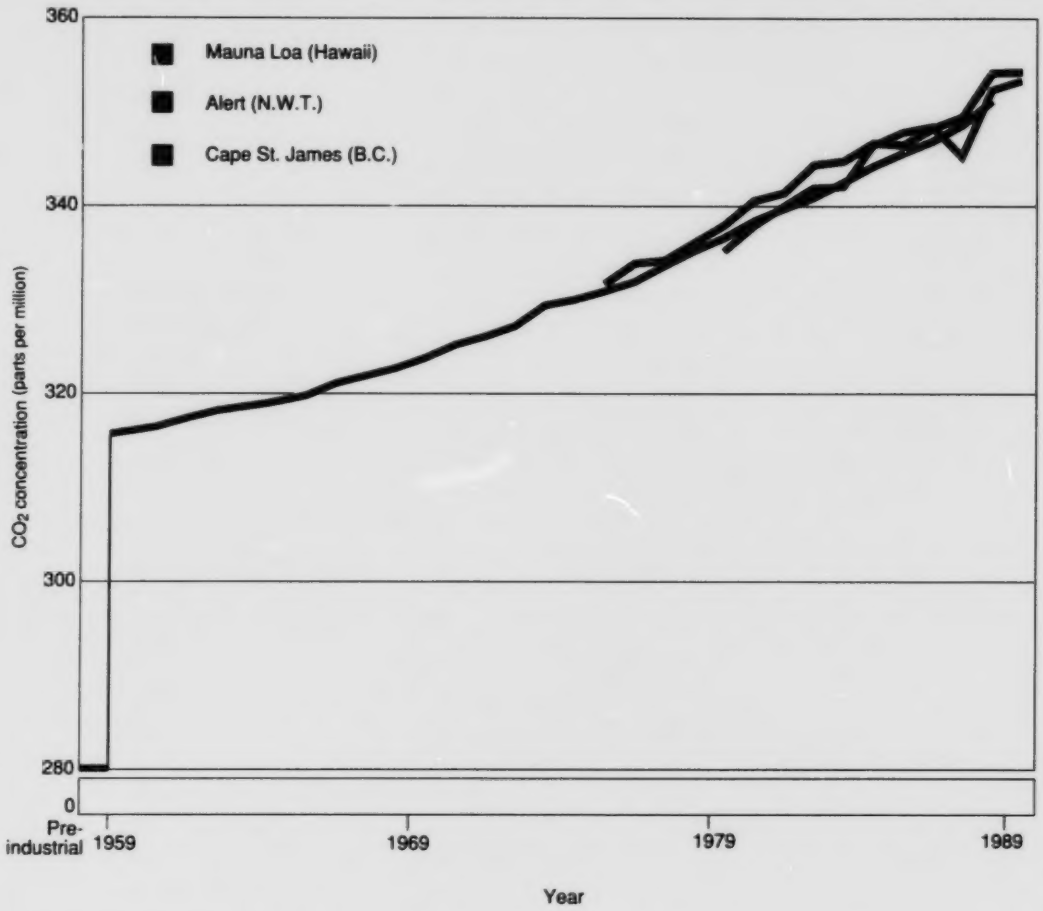
Emissions of carbon dioxide (CO_2), the most important of the greenhouse gases, are closely tied to the consumption of fossil fuels, such as coal, oil, and natural gas. In Canada, as well as globally, emissions of CO_2 have been increasing steadily. Between 1920 and 1989, Canadian CO_2 emissions from energy (which constitute over 90% of total Canadian CO_2 emissions) have increased by about 500%. The rate of increase accelerated in the period after 1945, coincident with increases in economic growth and fossil fuel use. On a per capita basis, Canadian emissions of CO_2 and other greenhouse gases were among the highest of the countries belonging to the Organisation for Economic Co-operation and Development (OECD) in 1987. Globally, anthropogenic CO_2 emissions have more than tripled since 1950. Responsibility for these emissions is widely shared among major world regions.

Canada recently announced its intention to stabilize emissions of CO_2 and other greenhouse gases at 1990 levels by the year 2000.

Indicator

Atmospheric concentrations of carbon dioxide (CO_2)

Target Not defined



Atmospheric CO_2 concentrations

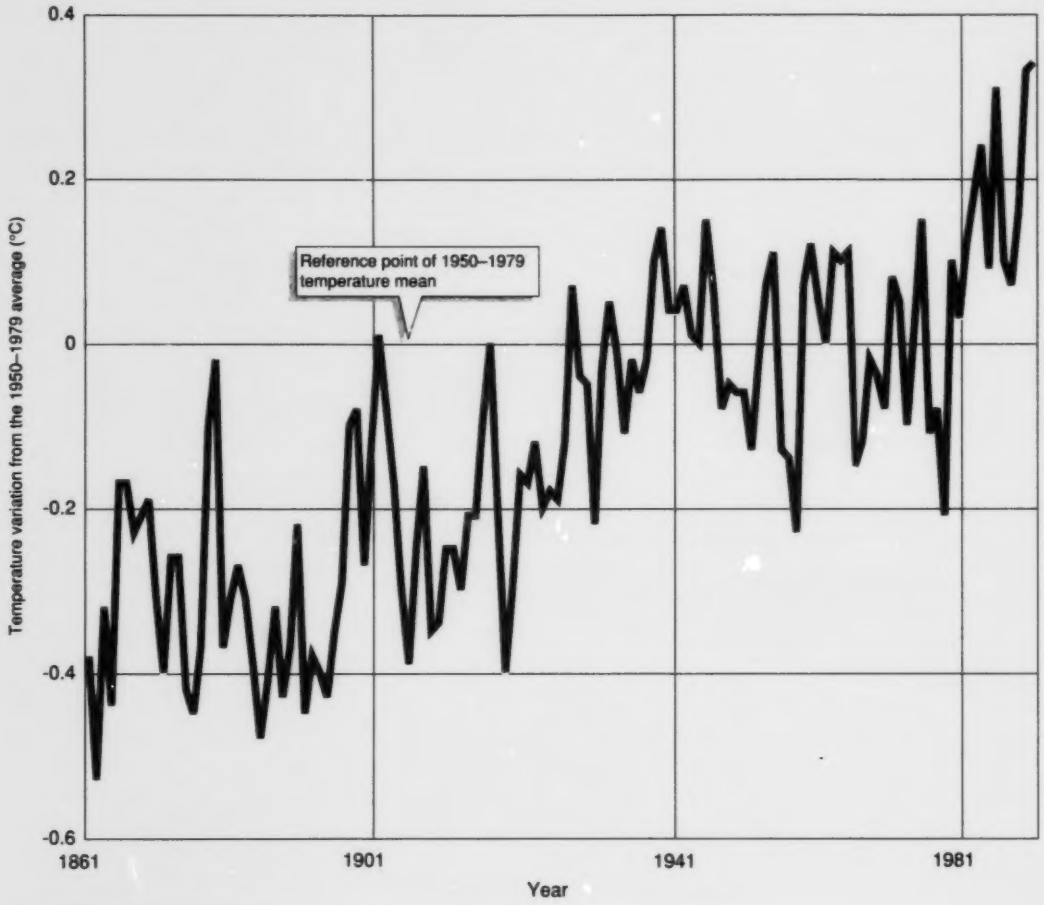
Source: Environment Canada, Atmospheric Environment Service (Alert and Cape St. James data); Scripps Institute of Oceanography (Mauna Loa data)

Several of the greenhouse gases occur naturally in the atmosphere (e.g., water vapour, carbon dioxide [CO_2], methane, nitrous oxide), but others are entirely of human origin (e.g., chlorofluorocarbons). The concentrations of the various greenhouse gases in the atmosphere have varied over time. However, human activities have significantly increased the rate of change in their concentrations. The CO_2 concentration of about 350 parts per million in the late 1980s is about 20–25% higher than at any time in the past 160 000 years (concentrations during the previous ice age dropped to around 200 parts per million). By the beginning of the industrial revolution, CO_2 concentrations had risen back to 280 parts per million. Within the past 100 years, CO_2 concentrations have risen by a further 70 parts per million, with more than half of this increase occurring in the last 30 years.

As these gases increase in amount, they are expected to enhance the natural greenhouse effect and substantially alter the global climate.

Indicator
Global air temperature

Target Not defined



Global temperature variations, 1861–1988

Source: Jones *et al.* 1990

Variations in global air temperature are commonly used to identify climatic change resulting from such factors as changes in carbon dioxide (CO_2) concentrations, solar output, and explosive volcanic eruptions. Climate projections, based on complex computer calculations, suggest that average world temperatures could increase between 1.5 and 4.5°C if global CO_2 concentrations were doubled. Warming in Arctic regions would be 2–3 times greater than in the tropics, causing a change in global heat distribution.

Records of global and hemispheric temperature variation since 1861 show little change during the 19th century, marked warming to 1949, and relatively steady conditions to the mid-1970s, followed by a rapid warming during the 1980s. Statistically, the global temperature has been significantly higher in the decade of the 1980s than the mean temperature of the period 1950–1979. The warmest 6 years of the 1861–1988 period have been, in descending order, 1988, 1987, 1983, 1981, 1980, and 1986. Many climatologists believe that the long-term warming trends seen in the temperature records are most likely the result of increased concentrations of greenhouse gases.

Stratospheric Ozone Depletion

The stratosphere, that portion of the atmosphere between 12 and 50 km above the Earth's surface, contains the ozone layer. Here, ozone is a naturally occurring gas whose concentration increases with altitude, reaching maximum values in a layer between 15 and 35 km above the planet's surface.

Stratospheric ozone acts as the world's sunscreen by absorbing most of the sun's damaging ultraviolet rays. The less ozone there is in the stratosphere, the more ultraviolet radiation is allowed to reach the Earth's surface, where it exerts adverse effects. Ultraviolet radiation is known to cause some forms of skin cancer, suppress the human immune system, and accelerate skin and eye ageing in humans and animals. Crops such as wheat, rice, corn, and soya beans are sensitive to exposure to ultraviolet radiation. An increase in this type of solar radiation can also disrupt the marine food chain, thereby decreasing oceanic production. Even manufactured products such as paints and plastics have exhibited degradation due to increased exposure to ultraviolet rays.

Stratospheric ozone is spread very thinly, with maximum concentrations in the range of 10 parts per million. Ozone is also a very unstable substance and can be easily destroyed by contact with certain air pollutants. These two facts point to the very fragile nature of the ozone layer. There has been concern for some time now that manufactured chemicals are reaching the stratosphere and threatening the planet's ozone layer. Chlorofluorocarbons, which are stable and environmentally safe in the lower atmosphere, are broken down by ultraviolet light in the stratosphere and release chlorine. A single molecule of chlorine can destroy thousands of molecules of ozone.

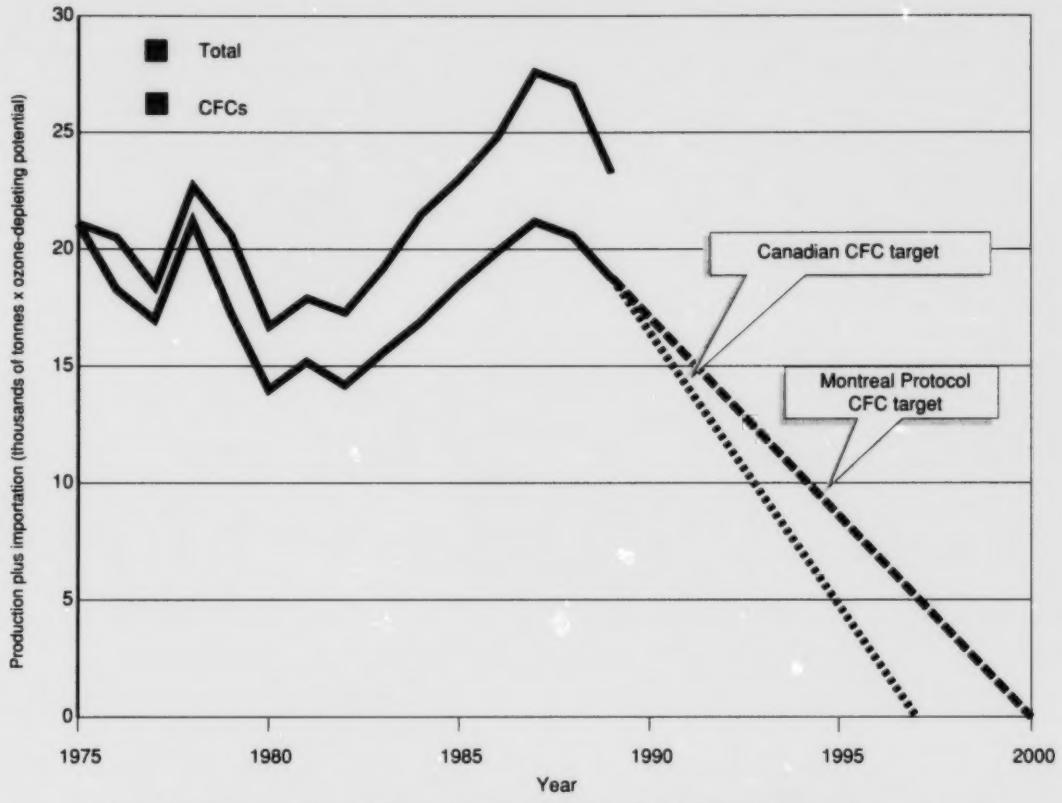
The following indicators for stratospheric ozone depletion are presented:

* Canadian production and importation of ozone-depleting chemicals
* Stratospheric ozone levels

Indicator
Canadian production and importation of ozone-depleting chemicals

Targets

(1) Montreal Protocol Agreement: 100% phaseout of production and importation of chlorofluorocarbons (CFCs), halons, and carbon tetrachloride by the year 2000; 100% phaseout of methyl chloroform by the year 2005.
(2) Canadian targets: Elimination of CFC production and importation by 1997; elimination of methyl chloroform production and importation by the year 2000.



Canadian production and importation of ozone-depleting chemicals

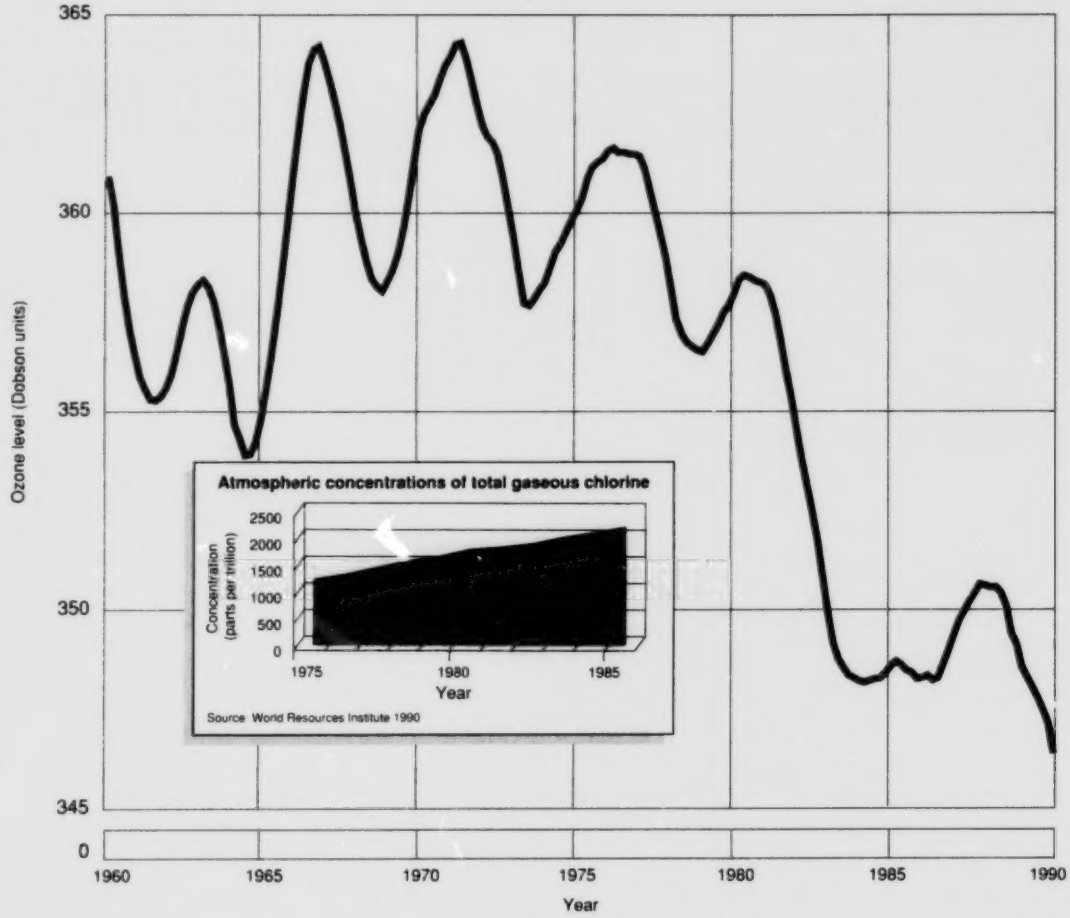
Source: Environment Canada, Commercial Chemicals Branch

Canadian consumption of ozone-depleting chemicals (chlorofluorocarbons [CFCs], halons, methyl chloroform, and carbon tetrachloride) increased by approximately 10% between 1975 and 1989. Consumer boycotts of aerosol sprays containing CFCs in the mid-1970s and restrictions on certain uses of CFCs enacted in 1980 significantly reduced demand for these chemicals. Consumption of CFCs and other ozone-depleting chemicals then increased, however, as these substances began to be used in an increasingly diversified range of products. More recently, demand has begun to decrease as substitute products are brought to market and as users recycle.

Since the mid-1980s, scientists have established with greater confidence the link between emissions of CFCs (and other ozone-depleting substances) and ozone depletion. International negotiations to protect the ozone layer culminated in 1987 with the Montreal Protocol, an agreement to reduce the world's consumption of ozone-depleting chemicals. A June 1990 amendment called for the elimination of production and importation of most of these chemicals by the year 2000. Canada has committed itself to a more ambitious CFC phaseout target—elimination of production and importation by 1997. Global reduction and elimination of CFC use will also assist in slowing global warming potential, as CFCs are potent "greenhouse gases."

Indicator
Stratospheric ozone levels

Target Not defined



Stratospheric ozone trend over Toronto, 1960–1990

Source: Environment Canada, Atmospheric Environment Service

Over the past decade, measurements at different locations on Earth have indicated a depletion of the ozone layer. As an example, measurements of ozone amounts in the stratosphere over Toronto, which are broadly representative of stratospheric ozone amounts at this latitude, have shown a decrease of between 3 and 4% since 1975. This is consistent with the discovery of an unexpected ozone "hole" over Antarctica, a drastic thinning (up to 50%) of the ozone layer during the polar spring.

The element chlorine facilitates the destruction of stratospheric ozone. Chlorine is found in chlorofluorocarbons, methyl chloroform, and other substances and can destroy ozone when these substances migrate to the stratosphere. Measurements taken between 1975 and 1985 show an 80% increase in stratospheric chlorine (chlorine contained in the ozone-depleting gases), which is an indicator of stress on the integrity of the stratospheric ozone layer. This concentration is expected to drop as the consumption of ozone-depleting chemicals is reduced.

Radiation Exposure

Real or potential exposure to radiation has attracted public concern over the years as a result of widespread atmospheric nuclear testing programs and the development of (and occasional accident at) nuclear power facilities. Releases of radioactivity on a global scale began with atmospheric nuclear weapons testing in 1946, with the bulk of testing occurring during the late 1950s and early 1960s. Residual radioactive fallout from this source has declined significantly since the cessation of widespread weapons testing in 1963. Nuclear reactors also generate large quantities of radioactivity, but there have been few significant releases, with the major exception of those from the nuclear reactor fire at Chernobyl, USSR, in 1986.

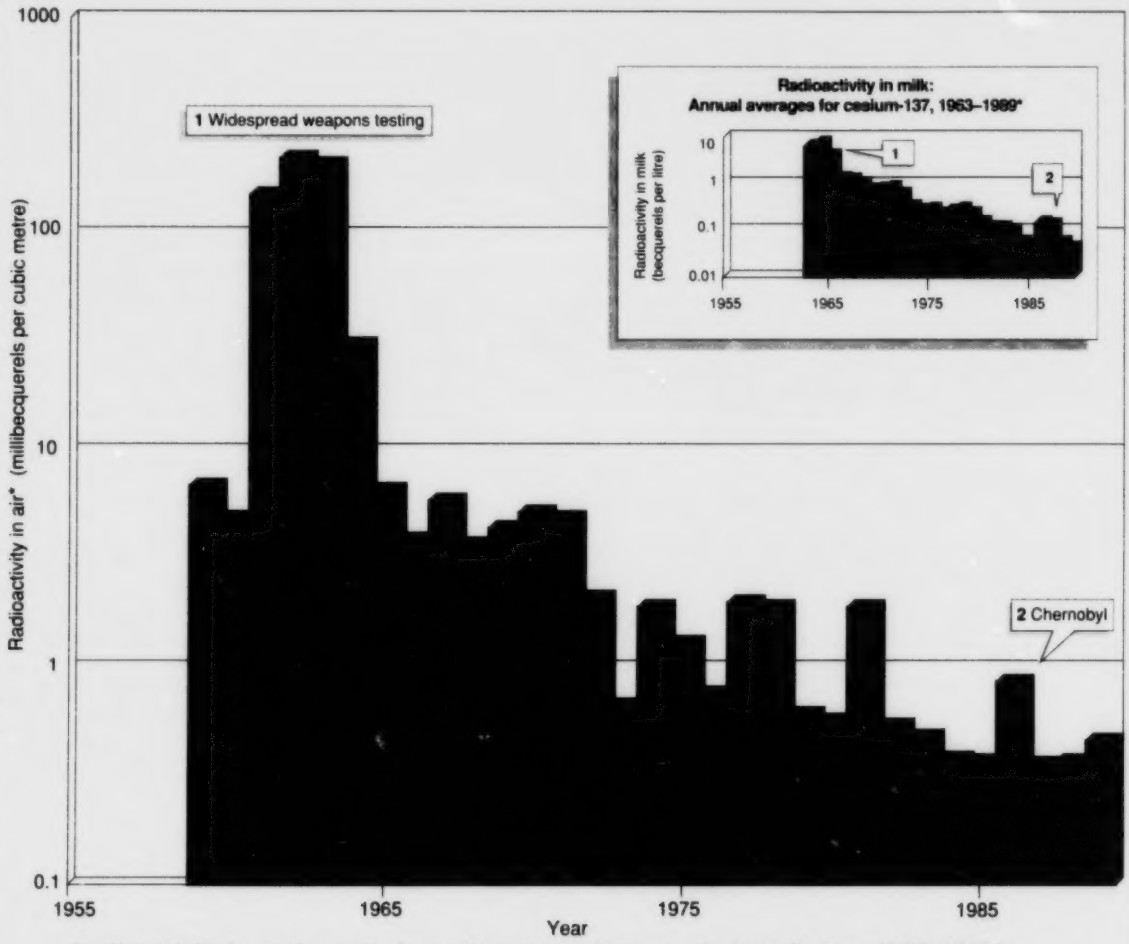
Concerns about exposure to radiation relate to ionizing radiation and its possible health effects on both present and future generations. Evidence of the harmful effects of exposure to excessive amounts of ionizing radiation has been thoroughly documented. However, the effects of exposure to small amounts of ionizing radiation are not well known. Exposure to radiation in small quantities is a natural phenomenon, although background levels vary, depending upon altitude and geological conditions. The International Commission on Radiological Protection has a mandate to develop and publish recommendations in relation to radiation exposure, but its standards apply to exposures from controlled sources rather than from ambient conditions.

The indicator for radiation exposure presented here is:

* Levels of radioactivity in the air

Indicator
Levels of radioactivity in the air

Target No targets for ambient levels of radioactivity defined



Radioactivity in surface air: Annual averages for gross beta radiation, 1959–1989*

* Geographically weighted average annual activity.

Source: Health and Welfare Canada, Health Protection Branch

High radioactivity levels in surface air resulting from widespread nuclear weapons testing in the 1960s are evident in the graph. The elevated readings of radioactivity from the 1970s up to 1981 are a result of atmospheric weapons testing by the People's Republic of China, which ended in October 1980. A rise in radioactivity after the Chernobyl nuclear reactor fire in 1986 is noticeable. Levels in recent years represent principally background activity from natural sources. Measurements for gross beta radiation are carried out weekly at 28 environmental network stations across Canada.

Trends in levels of radioactivity in milk are a useful indicator of health risk, because cumulative effects on health generally result from ingestion. The inset shows that levels of cesium-137 (Cs-137) in milk have also been declining since the bulk of atmospheric weapons testing ceased in 1963. Samples of whole milk are collected monthly from commercial outlets in 18 cities across Canada. As with surface air levels, radioactivity in milk rose after the 1986 Chernobyl accident; owing to a lag effect, elevated levels continued into 1987. By the end of 1987, levels had fallen to or below those found before the Chernobyl accident. The risk to humans from all levels recorded in Canada is insignificant.

Acid Rain

Acidic precipitation, better known as acid rain, is threatening fish and plant life in thousands of lakes, injuring plants, and reducing the vigour of trees. Research on health implications shows a link between high concentrations of acidic air pollution and respiratory problems in humans. In addition, this pollution eats away at stone statues, limestone buildings, and metal rooftops.

The causes of acid rain are emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) into the air, largely from smelters and power plants and, with NO_x, cars and trucks. If such emissions were reduced or eliminated, the effects of acid rain would be substantially reduced or eliminated.

In Canada, most of the acidic deposition is linked to SO_2 produced primarily in the refining and smelting of metal ores and, to a lesser extent, from the burning of oil and coal. As well, in much of southeastern Canada, a substantial portion of the problem results from the transboundary flow of SO_2 from the United States.

Acidic deposition is not as serious a problem in western Canada as in the east, because of lower overall emissions, the fact that the region is out of the path of the air flow from industrial sources in the United States, and a more acid-resistant environment.

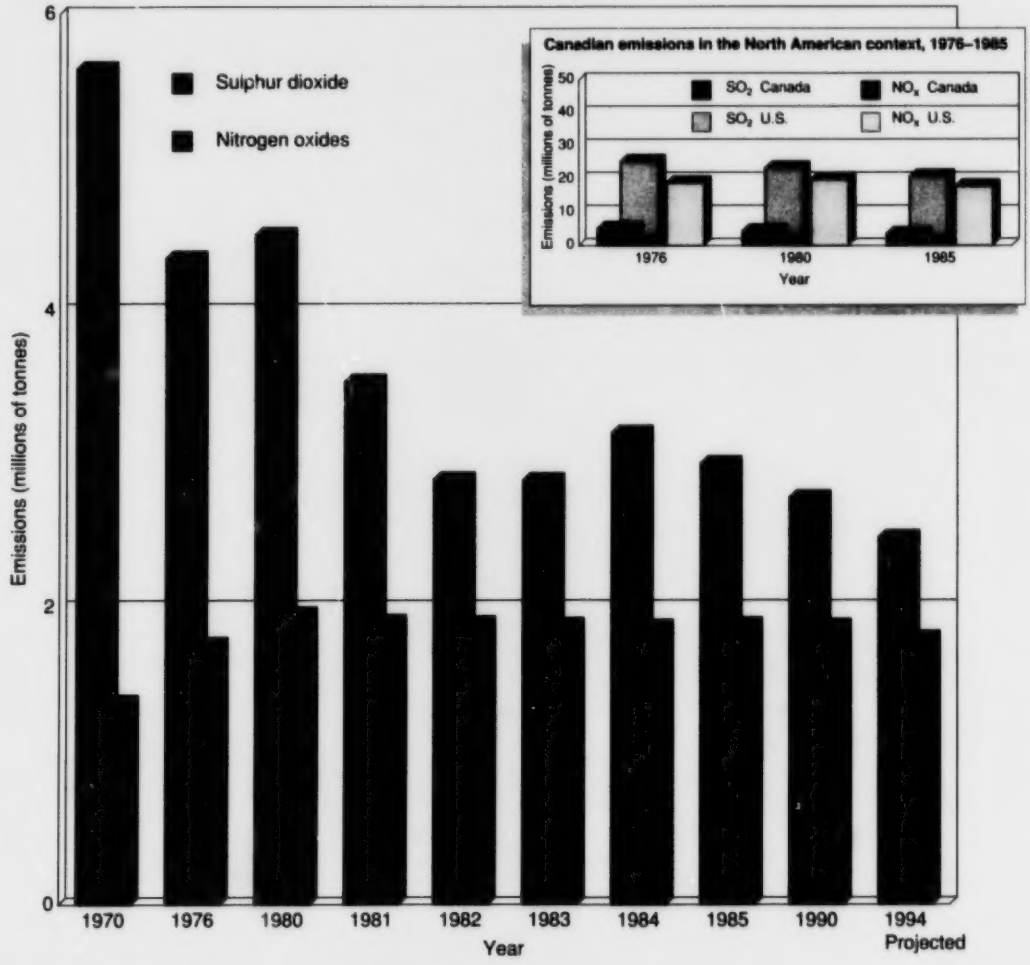
Emissions of NO_x in Canada are approximately half those of SO_2, and precipitation acidified by emissions of NO_x occurs to a lesser extent than precipitation acidified by emissions of SO_2. The main concern in Canada regarding NO_x is their role as precursors in the formation of ground-level ozone. Most large urban areas in the summer months experience levels of ozone that exceed Canadian standards for short periods of time. Research is currently under way to study the effects of nitrate deposition on receiving environments.

The indicator presented for acid rain is:

* Sulphur dioxide (SO_2) and nitrogen oxides (NO_x) emissions

Indicator
Sulphur dioxide (SO_2) and nitrogen oxides (NO_x) emissions

Targets (1) Canadian Control Program for Emissions of SO_2: The seven eastern provinces are to reduce total SO_2 emissions to 2.3 million tonnes from 4.5 million tonnes (1980 emissions) by 1994.
(2) United Nations Economic Commission for Europe international protocol: Canada is committed to "freezing" NO_x emissions in 1994 at 1987 levels (or about 2 million tonnes).



SO_2 and NO_x emissions in Canada

Source: Environment Canada, Industrial Programs Branch

This figure summarizes SO_2 emissions from eastern Canada and NO_x emissions from all Canada for the period 1970–1987. Projections are given to 1994. Overall, Canadian SO_2 emissions have fallen 45% since 1970, from 6.7 to 3.7 million tonnes. Because the bulk of Canadian SO_2 emissions occur in the seven eastern provinces, the Canadian Control Program has targeted reductions in these provinces. A 35% (1987) reduction has occurred in eastern Canada since 1980, the base year for the Control Program. More recent partial data indicate that over 80% of the 1994 objective has been achieved.

The inset compares Canadian and U.S. emissions for the years 1976, 1980, and 1985. Canadian SO_2 emissions in 1985 were about 18% of those in the United States (the last year comparative data were compiled). For NO_x, Canadian emissions, which are targeted for reduction under an international protocol, were about 10% of the U.S. totals. This proportion reflects the population difference between the two countries.

Outdoor Urban Air Quality

The quality of the air we breathe is a concern everyone shares. Poor air quality can adversely affect human health, damage vegetation and other forms of life, and accelerate the deterioration of buildings and monuments. Air pollution arises from many of the activities of our modern industrial society. Automobile use, energy production, industrial processes, agricultural practices, and solid waste incineration all result in the formation and release of air pollutants.

Common air pollutants found in the Canadian environment include photochemical oxidants such as ozone, carbon monoxide (CO), sulphur dioxide (SO_2), suspended particulates, and nitrogen oxides (NO_x). In addition, the atmosphere contains many thousands of less common organic and inorganic substances that, even though present at very low concentrations, have the potential to adversely affect human health and the environment. These substances are collectively referred to as toxic or hazardous air pollutants, or simply as "air toxics."

Air quality has been regulated in Canada since the 1970s under the Clean Air Act (now part of the Canadian Environmental Protection Act). The Act sets out National Ambient Air Quality Objectives for the common air pollutants and issues guidelines for emissions of these pollutants from specific sources (provincial governments also regulate emissions through licensing and monitoring). Air quality monitoring is carried out by the National Air Pollution Surveillance (NAPS) network, which collects pollutant concentration information from stations located in major urban centres across Canada. Although NAPS data indicate that national annual concentrations of common air pollutants are generally well below acceptable levels, National Ambient Air Quality Objectives have been exceeded numerous times at individual NAPS stations.

Environment Canada has published estimates of the emissions of common air pollutants from anthropogenic sources since 1970; data are compiled approximately every 5 years. Emissions estimates and ambient measurements for air toxics have been conducted on a less regular basis.

The following indicators are presented for outdoor urban air quality in Canada:

Common air pollutants

* Nitrogen dioxide (NO_2) and carbon monoxide (CO): Levels in urban air and emissions
* Sulphur dioxide (SO_2) and total suspended particulates (TSP): Levels in urban air and emissions
* Ground-level ozone concentrations

Air toxics

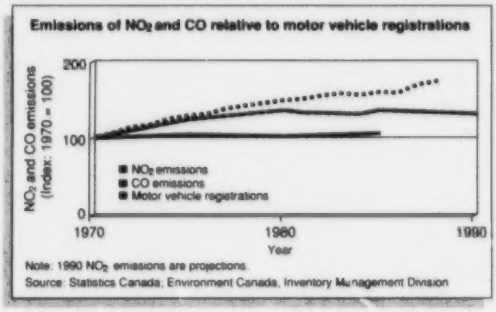
* Lead concentrations in urban air

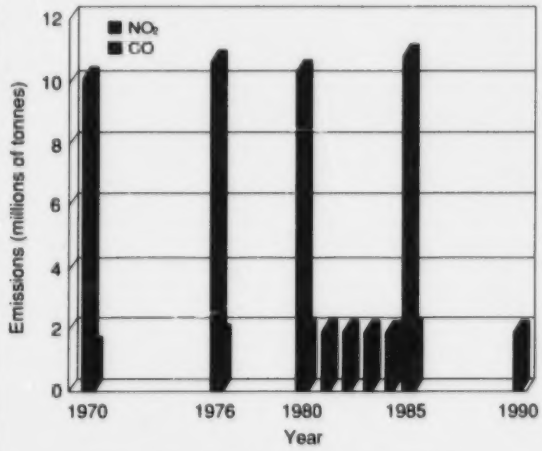
Indicator

Nitrogen dioxide (NO_2) and carbon monoxide (CO): Levels in urban air and emissions

Targets

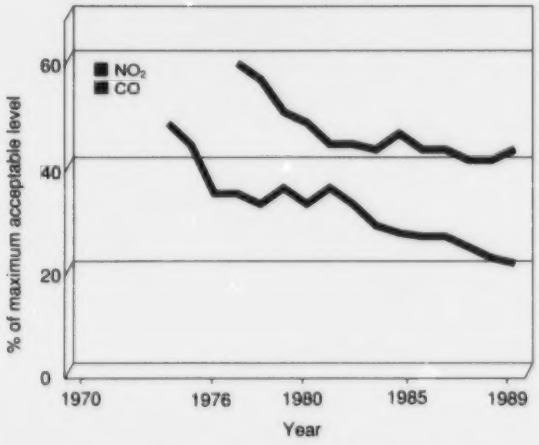
(1) National Ambient Air Quality Objectives: NO_2 — Annual maximum acceptable concentration in urban air is 53 parts per billion; CO — 8-hour maximum acceptable concentration in urban air is 13 parts per billion.
(2) NO_2 — International Oxides of Nitrogen Protocol: Total emissions of nitrogen oxides limited to 1987 levels by 1994; CO — Emissions targets are defined for motor vehicles.





Emissions of NO_2 and CO in Canada

Note: 1990 NO_2 emissions are projections.
Source: Environment Canada, Inventory Management Division



Ambient levels of NO_2 and CO in Canada

Note: The CO data in the figure refer to the average 8-hour CO concentration indexed to the maximum acceptable level, whereas the NO_2 data are the annual mean concentrations indexed to the maximum acceptable level.

Nitrogen oxides (NO_x) are commonly formed during high-temperature combustion. These pollutants can cause adverse health effects in humans and suppress vegetation growth. Carbon monoxide (CO) is a colourless, odourless, and poisonous gas that is produced by the incomplete combustion of carbon in fuels. Exposure to high CO levels is of particular concern to persons with circulatory problems, smokers, and anemics. The major source of both NO_x and CO emissions is fuel combustion in motor vehicles. Other sources include industrial processes, solid waste incineration, and fuel combustion in stationary sources such as power plants and for heating households and offices.

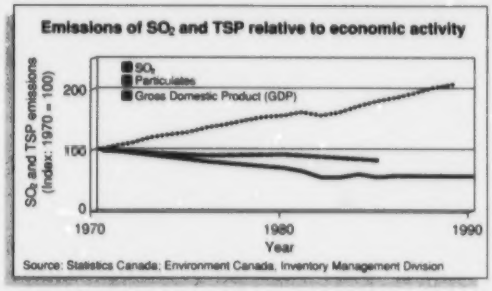
The NAPS data show that, over the last 15 years, ambient levels of nitrogen dioxide (NO_2) (the most important nitrogen oxide as far as health and environmental effects are concerned) and CO in urban areas have decreased by approximately 28% and 55%, respectively. This decline is attributed to more efficient motor vehicles and the use of pollution control devices. However, NO_2 emissions have increased in recent years, whereas CO emissions have remained relatively stable. The inset illustrates that increases in NO_2 emissions have been concurrent with a growth in the number of motor vehicles registered in Canada.

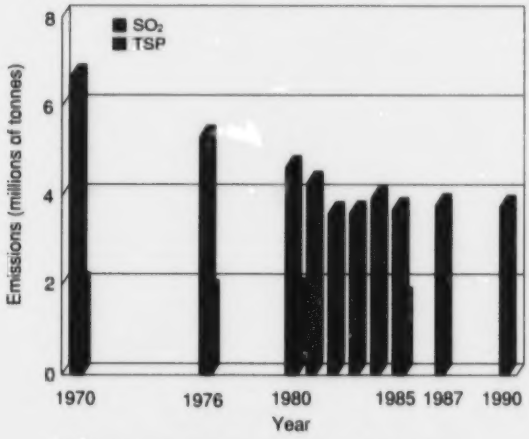
Indicator

Sulphur dioxide (SO_2) and total suspended particulates (TSP): Levels in urban air and emissions

Targets

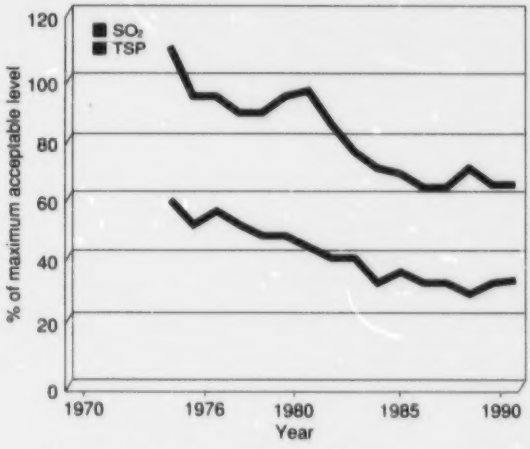
(1) National Ambient Air Quality Objectives: SO_2 — Annual maximum acceptable concentration in urban air is 23 parts per billion; TSP — Annual maximum acceptable concentration in urban air is 70 micrograms per cubic metre.
(2) SO_2 — Federal-provincial commitments to reduce emissions in eastern Canada to 50% of 1980 levels by 1994; TSP — Provinces define emissions targets for specific point sources.





Emissions of SO_2 and TSP in Canada

Note: SO_2 emissions for 1990 are projections.
Source: Environment Canada, Inventory Management Division



Ambient levels of SO_2 and TSP in Canada

Source: Environment Canada, Inventory Management Division

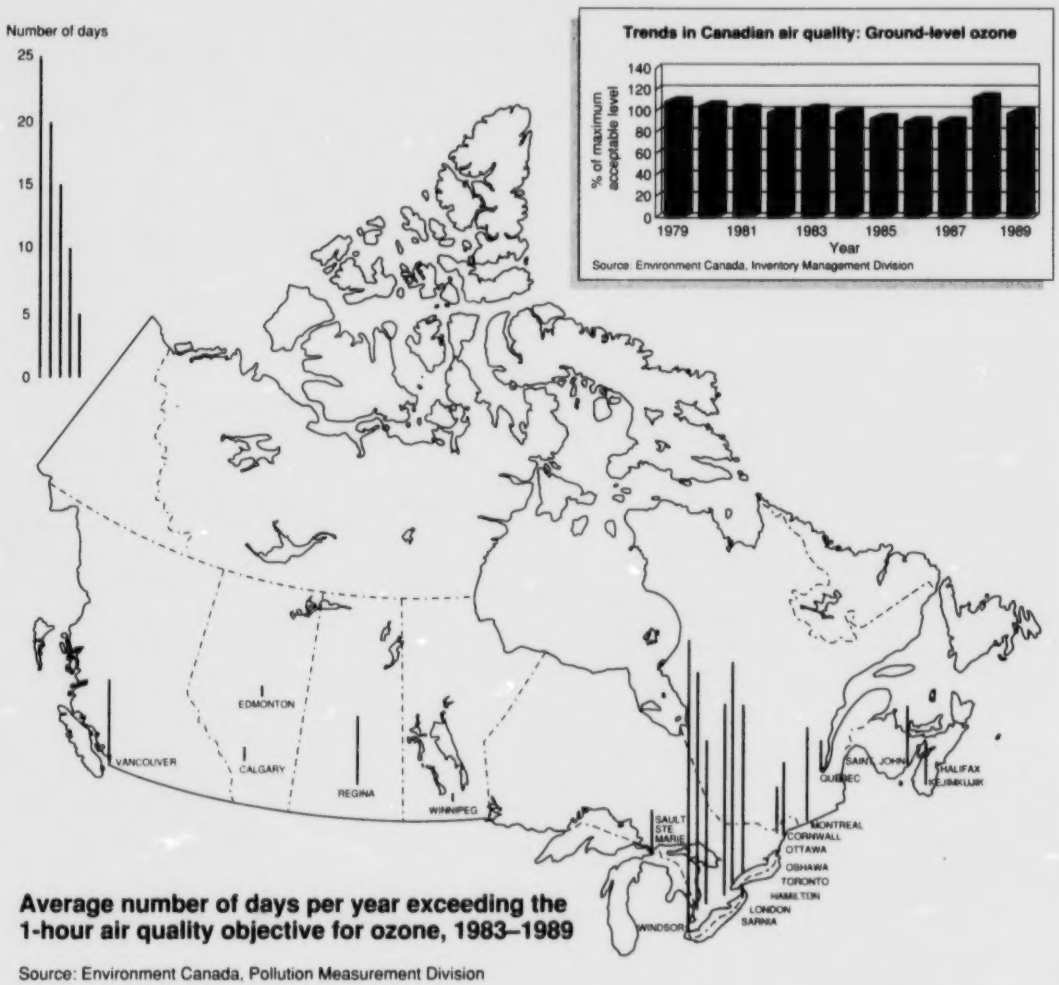
Sulphur dioxide (SO_2) is a colourless, pungent gas that arises from the combustion of sulphur-containing fuels, industrial processes, and volcanic eruptions. At concentrations exceeding maximum acceptable levels, SO_2 can damage vegetation and aggravate human respiratory diseases such as asthma and bronchitis. Suspended particulates are airborne particles that arise from natural sources such as volcanic ash and forest fires and from man-made sources such as smelting, pulp and paper production, thermal power generation, and agricultural practices. In high concentrations, suspended particulates can impair respiratory function, reduce visibility, and damage vegetation. Suspended particulates are also capable of carrying toxic trace substances. Industrial processes account for the majority of emissions of particulate matter and SO_2 in Canada.

Reduced emissions of SO_2 and suspended particulates have contributed significantly to the lowering of their ambient concentrations in urban centres. For the period 1974–1989, the NAPS monitoring stations recorded a 45% decrease in ambient concentrations of suspended particulates and a 52% decrease in ambient concentrations of SO_2. It should be noted, however, that some of the sources of these pollutants are outside major urban centres and are therefore not covered by the NAPS network.

The inset shows that the decrease in emissions and ambient urban concentrations of suspended particulates and SO_2 has been concurrent with a period of substantive economic growth.

Indicator
Ground-level ozone concentrations

Target National Ambient Air Quality Objectives: 1-hour maximum acceptable concentration is 82 parts per billion.



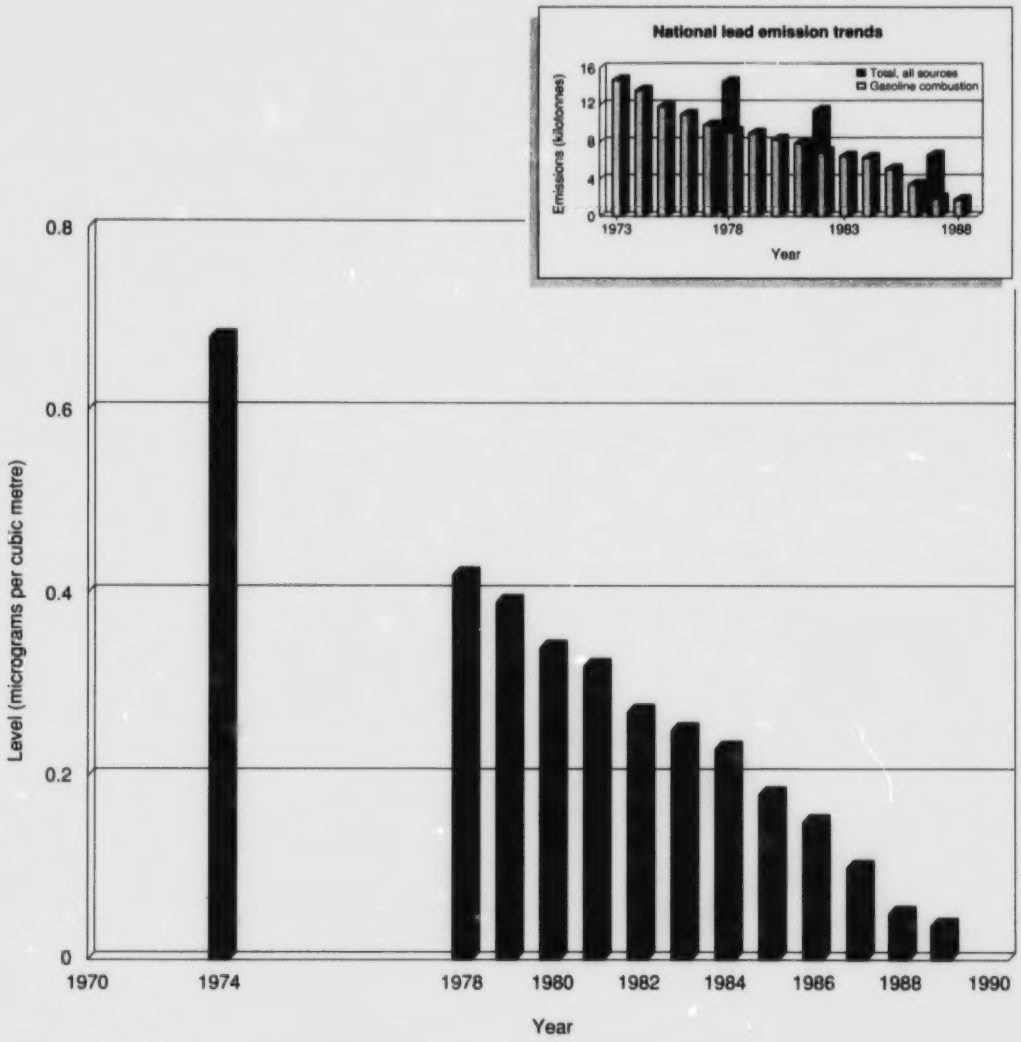
Ground-level ozone is a member of a class of air pollutants known as photochemical oxidants. Unlike the other common air pollutants, ozone is not emitted as a pollutant; rather, it is formed by a complex series of reactions involving nitrogen oxides, volatile organic compounds, and energy from sunlight. Repeated short-term or acute exposure to ozone levels of 100 parts per billion can cause damage to lungs of infants. In addition, ground-level ozone can cause damage to vegetation and reduce crop yields.

The National Ambient Air Quality Objectives set out the maximum acceptable concentration for ozone in Canadian cities. This objective is intended to provide protection against adverse effects on vegetation, materials, wildlife, visibility, and personal comfort and well-being. The figure depicts the average number of days ozone exceeded the 1-hour maximum acceptable level at NAPS monitoring stations. In cities with more than one monitoring station, the station with the highest average was used.

The NAPS data indicate that the annual average of high ozone levels has consistently hovered around the maximum acceptable level for the last decade (see inset). The peak in 1988 is attributed to higher than normal summer temperatures.

Indicator
Lead concentrations in urban air

Target Not defined



National trends in lead levels in urban air

Source: Environment Canada, Inventory Management Division

As a natural element, lead is found throughout the environment in concentrations that can vary widely. Most of the lead found in the environment is in a form unavailable to living organisms. However, "bioavailable" lead (lead that can be taken up by living organisms) poses a health risk. In humans, exposure to high lead concentrations can lead to accumulation of lead in body tissues and damage to the central nervous system.

Because of concerns about lead's adverse health effects, strategies to reduce emissions of lead generally and from gasoline in particular have been in place since 1974. Emissions of lead from gasoline peaked in 1973 at over 14 000 tonnes (about 70% of total lead emissions) and have been in decline ever since. In 1990, lead use in gasoline was phased out in Canada. Emission controls have thus far resulted in significant lowering of lead levels in urban air.

Water

Freshwater Quality

Much of the current concern with regard to environmental quality is focussed on water because water is essential to the maintenance of human health and the health of the ecosystem. Water bodies have generally provided a convenient sink for the direct disposal of wastes generated by urbanization and industrialization and have absorbed the runoff from land-based activities, such as forestry, agriculture, and mining. These same waters are required to support our fish and wildlife resources and to supply our drinking water.

Increasingly, public concern is being expressed about contaminants that do not break down but are taken up by living organisms and move up the food chain. Such chemicals are ubiquitous in the environment, and exposure pathways include soil, food, air, and both surface water and groundwater.

Drinking water is a potential pathway for contaminants in terms of human health. Provincial and municipal governments are responsible for ensuring that drinking water meets provincial standards, but their data are not readily usable for compiling a national picture. Consequently, a comprehensive national database for drinking water is not available at this time. Therefore, the percentage of population served by treated water supplies is presented as an indicator.

The remaining indicators portray some of the major stresses on the nation's waterways — for example, industrial and municipal point source discharges, as well as the water quality conditions downstream from urban and agricultural runoff (non-point sources).

The federal government regularly collects discharge data for federally regulated industries under the 1988 Canadian Environmental Protection Act and maintains an inventory of municipal water and wastewater treatment facilities. These data are used to present a national profile for select industrial and municipal discharges. The addition of provincial data for other industries would increase the scope and comprehensiveness of future indicators on pollutant loadings to the aquatic environment.

Non-point sources of contaminants in water are many and varied. The water quality indicators presented here focus on nutrients and pesticides associated with urban and agricultural runoff because these may contribute to water quality conditions that affect aquatic life, particularly fish.

Excess concentrations of such nutrients as phosphorus and nitrogen contribute to eutrophication (the excessive growth of algae in rivers and lakes). A consequence of this excessive growth is the depletion of dissolved oxygen, which is required by aquatic life for survival. In general, it is easier to regulate phosphorus inputs to aquatic systems than nitrogen inputs. Phosphate regulations under the 1970 Canada Water Act and the installation of phosphorus removal facilities at municipal sewage treatment plants (an important point source) have helped reduce phosphorus levels in, for example, the Great Lakes. The major sources of nitrogen are more diffuse, including atmospheric deposits and agricultural runoff.

The use of pesticides has been an issue of national public concern for some years. The class of pesticides (organochlorine insecticides) that gave rise to these concerns has been largely discontinued because of their persistence in the environment and their propensity to bioaccumulate and cause toxic effects in higher organisms (e.g., game fish, birds, mammals). Nevertheless, residual levels of many of these "old" pesticides, such as DDT, DDE, mirex, and endosulfan, continue to be found in sediments and biota in the aquatic environment, although they have not been found in the water column at any appreciable level in the last 10 years. New generations of pesticides have been, and are continually being, developed and used. Several widely used pesticides have been selected as indicators of non-point source contamination.

The indicators for eutrophication and pesticide contamination presented here are intended not to provide a "national" picture but rather to portray conditions at sites where water quality could be expected to be degraded because of urban and agricultural runoff and discharges from municipal sewage treatment plants.

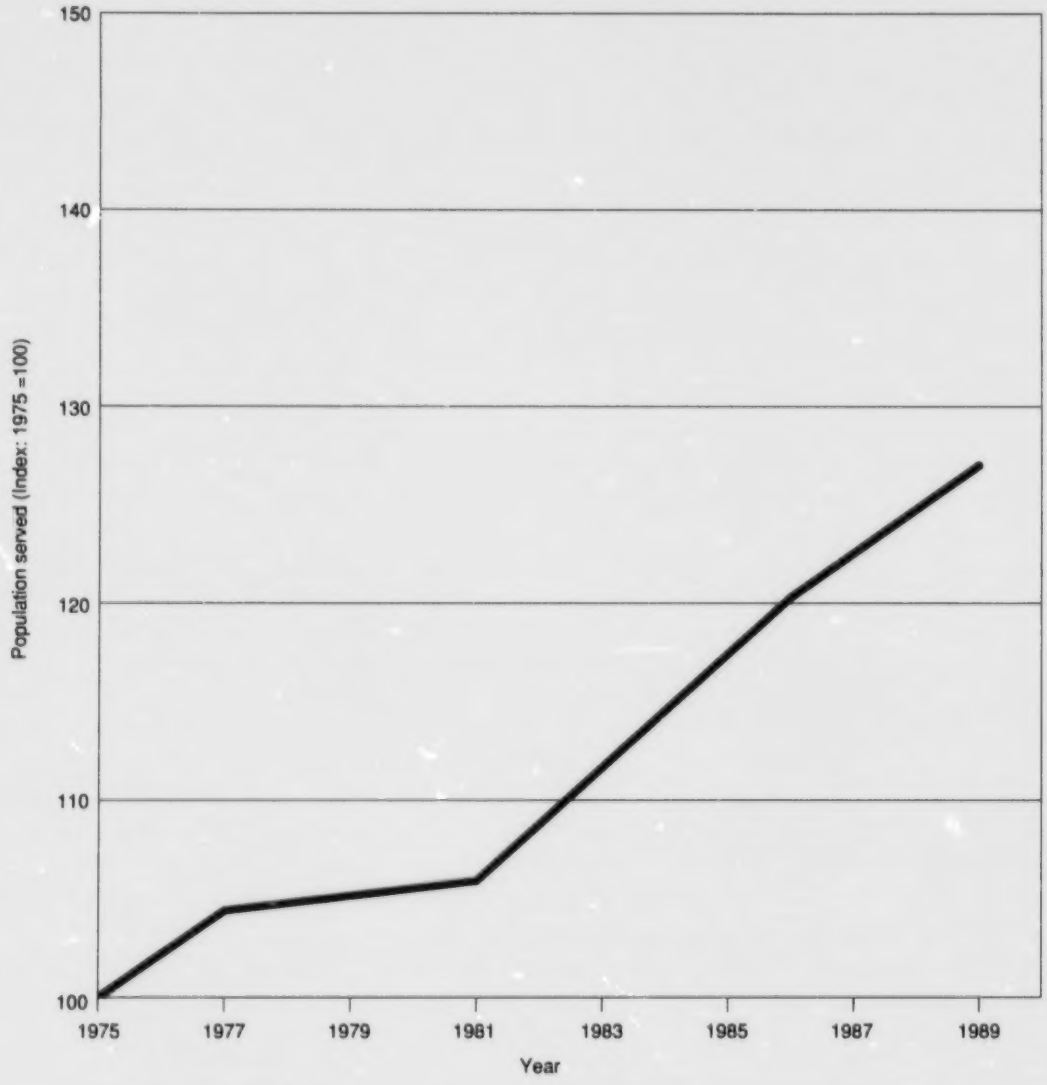
It is not possible at this time to provide concise, yet comprehensive, national trends for water quality. First, there is tremendous temporal and geographic variation in natural water quality across Canada in both surface water and groundwater supplies. Second, past and current water quality monitoring is not designed to support environmental reporting but rather to address local and regional needs. The definition of such needs and supporting monitoring vary from province to province. Furthermore, federal monitoring activities cannot provide a national overview, as they are restricted to international or interprovincial boundary waters unless otherwise provided for by special federal–provincial agreements. Consequently, it is difficult to find consistent data sets across all regions of Canada.

The indicators presented for freshwater quality are:

* Population served by treated water supply
* Municipal discharges to fresh water: BOD (biochemical oxygen demand), TSS (total suspended solids), and phosphorus
* Pulp and paper mill discharges to fresh water: TSS and BOD
* Discharges of regulated substances by petroleum refineries to water
* Concentrations of phosphorus and nitrogen in water
* Maximum observed concentrations of pesticides in water: 2,4-D, atrazine, and lindane

Indicator
Population served by treated water supply

Target Not defined



Population served by treated water supply*

*Data are based on population surveyed: 1975 (base year) — 16 284 627.

Source: Environment Canada, MUNDAT database

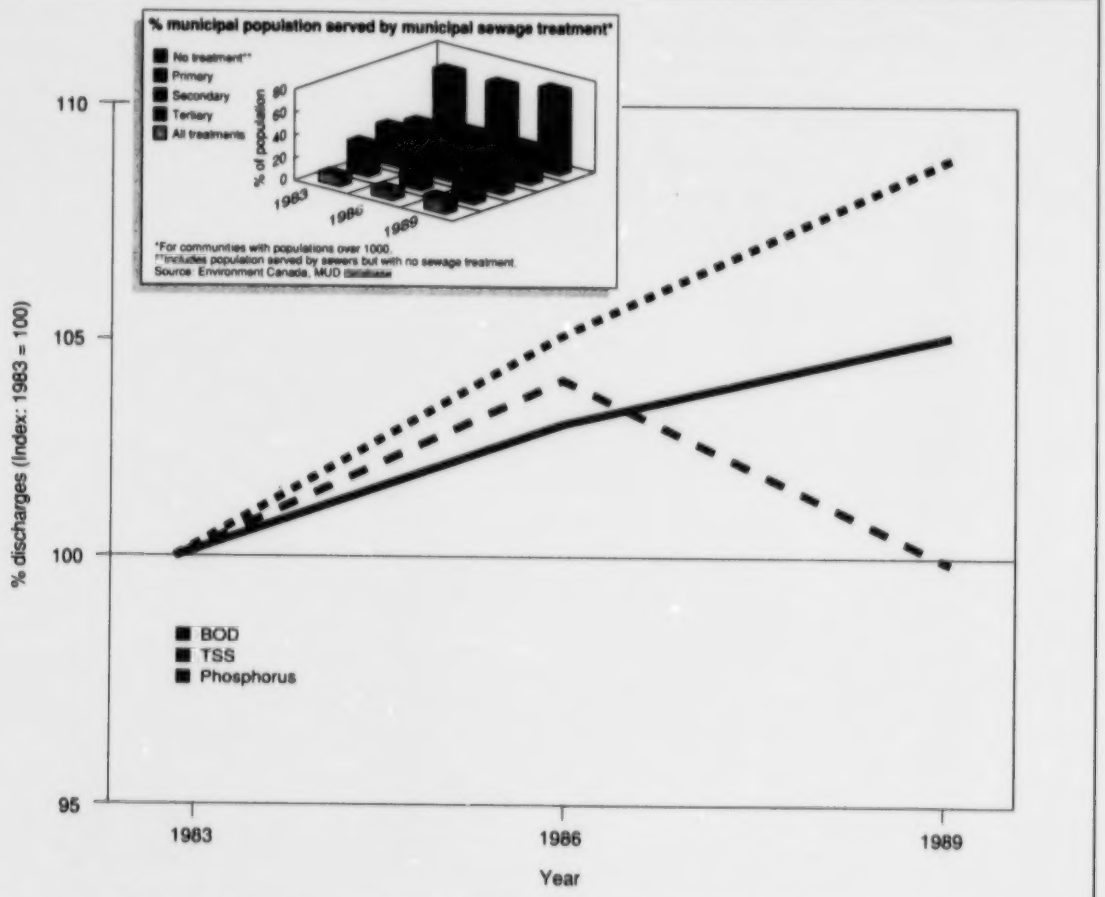
There is no systematic national monitoring program to measure contaminants in drinking water. However, Health and Welfare Canada established Guidelines for Canadian Drinking Water Quality in 1978 to provide maximum acceptable limits for contaminants in provincial and municipal drinking water supplies. Provincial and municipal governments are responsible for establishing and enforcing drinking water quality standards within their respective jurisdictions.

The population served by treated water supplies increased by 27% from 1975 to 1989. Water treatment facilities served 93.4% of the population surveyed (22 129 756 people) in 1989. The remainder of the population is served by private water systems.

Indicator

Municipal discharges to fresh water: BOD (biochemical oxygen demand), TSS (total suspended solids), and phosphorus

Target Dependent upon local conditions



Municipal discharges of BOD, TSS, and phosphorus to fresh water

Source: Environment Canada, MUD database, for sewage flow data; Waste Management Branch, for waste removal coefficients

Municipal sewage is a major source of water pollution, as it contains suspended solids, nutrients, heavy metals, and disease-carrying bacteria. It is also the major source of increased biochemical oxygen demand (BOD), which contributes to eutrophication, a condition that reduces oxygen availability for aquatic life.

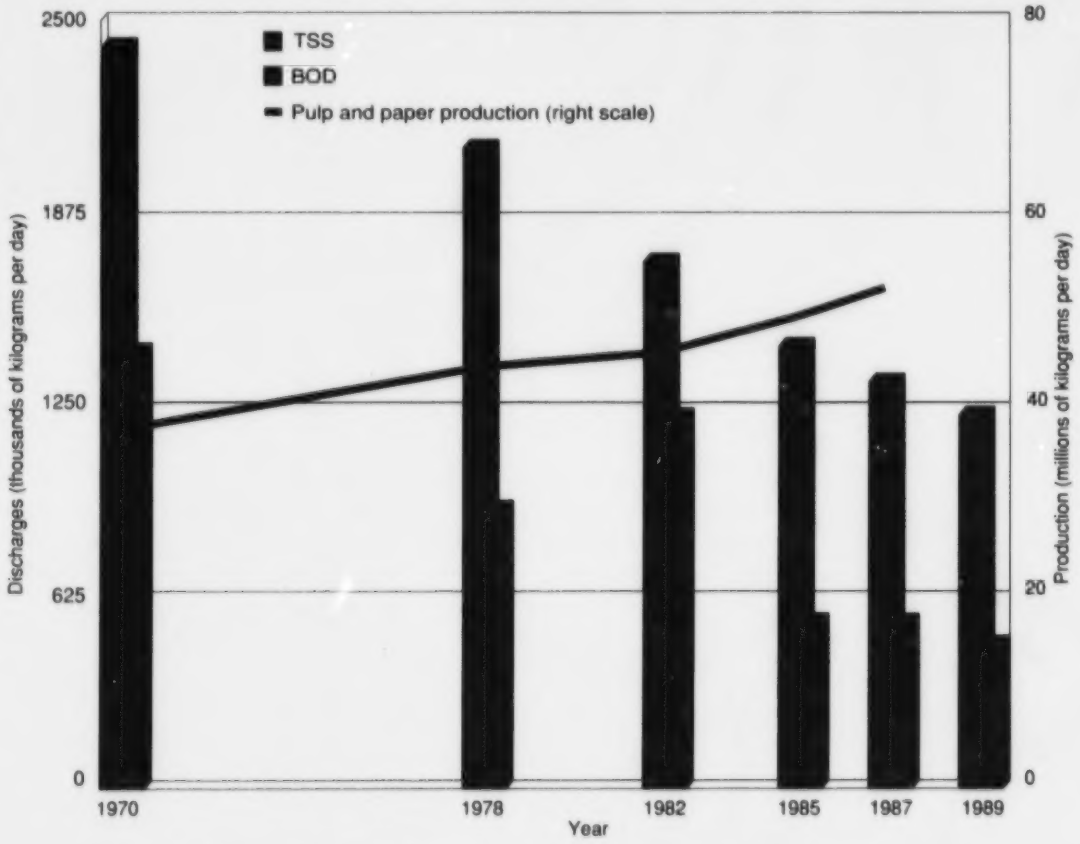
Given the level of sewage treatment, it is possible to estimate the amount of organic wastes (measured by BOD), total suspended solids (TSS), and phosphorus discharged to water. The graph indicates that, despite the increase in secondary and tertiary treatment levels, phosphorus discharges have increased since the base year 1983. There are insufficient national long-term data to determine if this increase over the period 1983–1989 is representative of a longer-term trend.

As shown in the inset, the percentage of the surveyed population (communities with more than 1000 people) served by sewage treatment plants that discharged to fresh water increased from 66% in 1983 to 73% in 1989. In 1989, 15.7 million people were served by some level of sewage treatment; of these, about 13.5 million lived in inland municipalities; the remainder lived in communities discharging to coastal waters. This information is based on municipal water use surveys conducted by the Inland Waters Directorate, Environment Canada, every 3 years since 1983.

Indicator

Pulp and paper mill discharges to fresh water: TSS (total suspended solids) and BOD (biochemical oxygen demand)

Target Under revision



TSS and BOD discharges to fresh water from Canada's pulp and paper industry

Source: Environment Canada, Industrial Programs Branch

The wastes discharged into fresh water by pulp and paper mills place considerable stress upon aquatic life. Three mill discharges of major concern are:

(1) Chlorinated organic compounds, such as dioxins and furans

(2) Total suspended solids (TSS), such as fibre, bark, etc., which may destroy fish habitat

(3) Organic wastes that deplete the oxygen available for fish (measured as biochemical oxygen demand, or BOD).

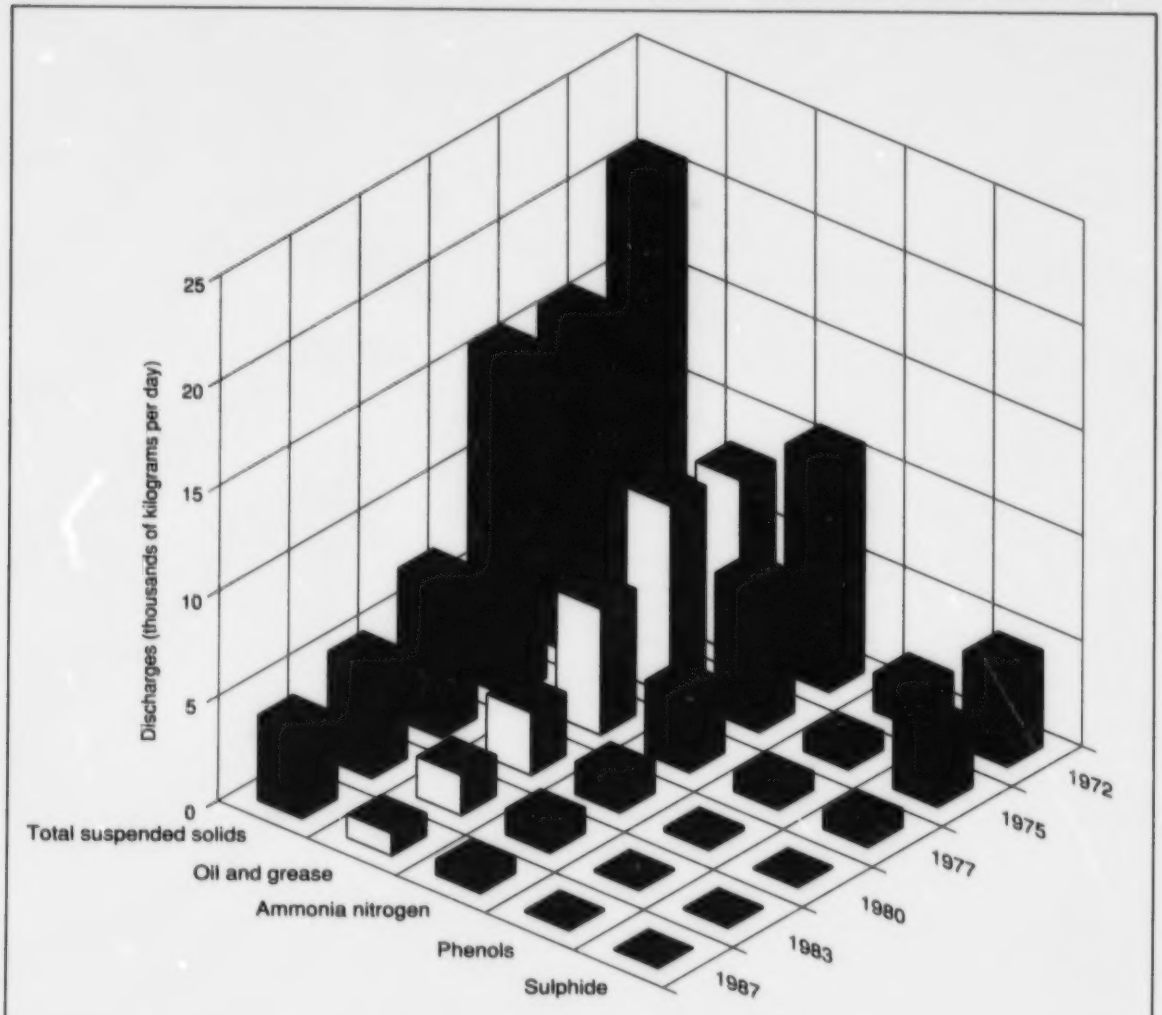
Long-term trend data are available for only BOD and TSS. Discharges of chlorinated organic compounds are not monitored on a regular basis.

The graph compares discharges of TSS and BOD with pulp and paper production. Discharges of TSS and BOD have decreased by 67% and 50%, respectively, for the period 1970–1987. Over the same period, pulp and paper production increased by about 47%.

Current federal regulations under the Fisheries Act apply only to mills built or improved since 1971. Revisions to the pulp and paper regulations, to be enacted in 1991, will apply to all mills in Canada and call for further decreases in TSS and BOD discharges and the virtual elimination of dioxin and furan discharges.

Indicator
Discharges of regulated substances by petroleum refineries to water

Target Compliance with Petroleum Refinery Effluent Regulations and Guidelines under the Fisheries Act



National net discharges of liquid waste by the Canadian petroleum industry, 1972–1987

Source: Environment Canada, Industrial Programs Branch

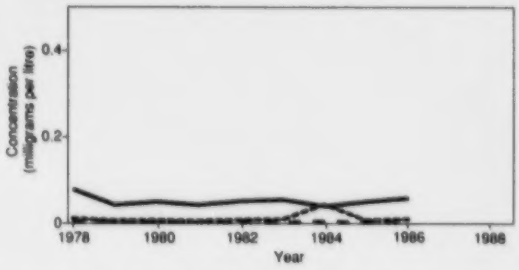
Discharges by the petroleum refining industry are monitored by Environment Canada under the Petroleum Refinery Effluent Regulations and Guidelines issued in 1973 under the federal Fisheries Act to protect fish and marine organisms. Maximum allowable discharges of the regulated substances vary among refineries, based upon production.

For 1987, the 29 refineries in Canada were in compliance with monthly discharge levels 94% of the time. There has been a steady downward trend in discharge levels of all substances since 1975 because of the industry's efforts to improve effluent treatment.* By 1987, about 76% of the refineries had secondary treatment systems. Approximately 30% of the refineries in 1987 discharged to coastal waters.

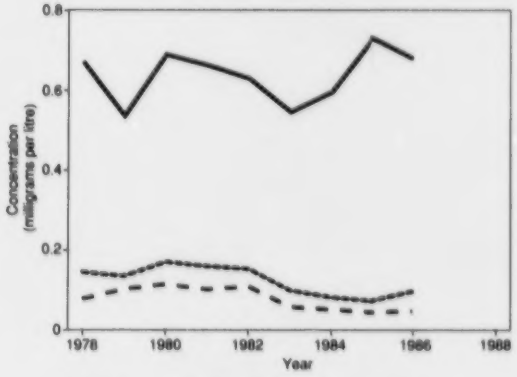
*Actual data for effluent discharges show a larger variation than the data presented here. For a more detailed assessment of annual deposits, see Losier (1990).

Indicator
Concentrations of phosphorus and nitrogen in water

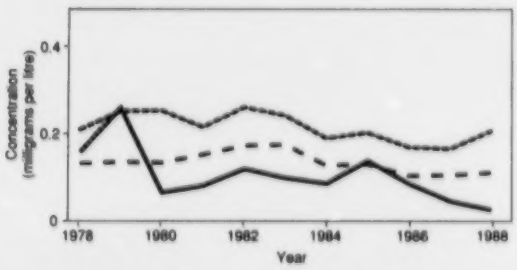
Target (1) National guidelines for phosphorus and nitrogen not defined to protect aquatic life.
(2) National guideline for total nitrogen in drinking water is 10 milligrams per litre.



Annual average concentrations in the Bow River, Alberta, upstream of Calgary



Annual average concentrations in the Bow River, Alberta, >300 kilometres downstream of Calgary



Annual average concentrations in the Qu'Appelle River, Saskatchewan, at the Saskatchewan–Manitoba border

Nitrate + nitrite
Total phosphorus
Dissolved phosphorus

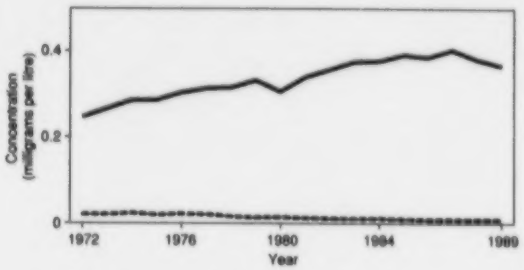
Source: Environment Canada, NAQUADAT database

In general, both phosphorus and nitrogen are required by algae for growth. However, the total amount of growth is controlled by only one nutrient at a time, and this is determined by the ratio between the two.

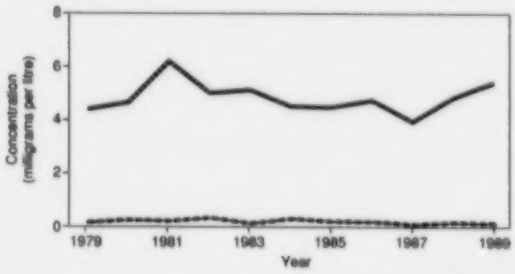
It is difficult to arbitrarily set a concentration of phosphorus that will prevent eutrophication or excessive algal growth because this is influenced by a number of other factors, such as light availability and flow rates. Consequently, the amount of algal growth in waters can vary widely across the country, even though nutrient concentrations may be similar.

The Prairie Provinces Water Board has established a total phosphorus objective of 0.05 milligrams per litre. The Qu'appelle River has fairly consistently exceeded this threshold

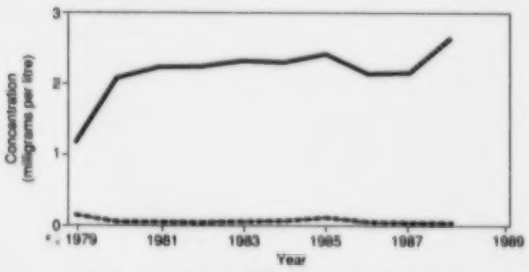
Indicator
Concentrations of phosphorus and nitrogen in water *(continued)*



Spring average concentrations in Lake Ontario, midlake region



Annual average concentrations in the Thames River, Ontario, near its mouth



Annual average concentrations in the Dunk River, Prince Edward Island

Nitrate + nitrite
Total phosphorus

Source: Environment Canada, NAQUADAT database

for phosphorus.* The Bow River downstream has shown improvement since 1982. The Thames River has been exceeding the Ontario guideline of 0.03 milligrams per litre. An objective of 0.01 milligrams per litre for total phosphorus was set for Lake Ontario to restore the lake to a non-eutrophic state. This level has been achieved since 1986 for the midlake region.

The Prairie Provinces Water Board has established a total nitrogen objective of 0.5 milligrams per litre for Prairie rivers. The graph for the Bow River downstream of urban and agricultural areas shows that this level is exceeded fairly consistently. An objective for nitrogen for Lake Ontario has not been established because phosphorus, rather than nitrogen, is the controlling factor for algal growth in this ecosystem. None of the sites exceeds the Guidelines for Canadian Drinking Water Quality for total nitrogen.

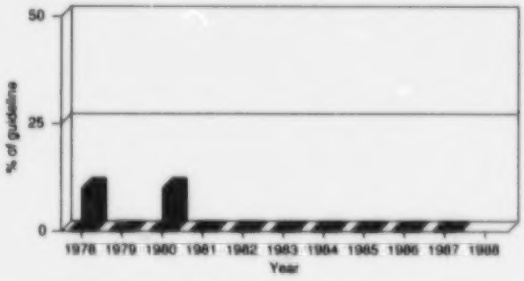
*Total phosphorus includes types of phosphorus compounds that cannot be used by algae. Dissolved phosphorus is a better measure of the amount of this nutrient that can be used by algae, and this has been reported where available.

Indicator

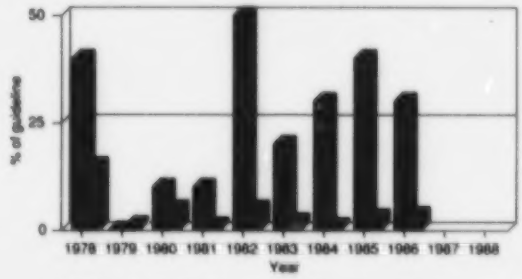
Maximum observed concentrations of pesticides in water: 2,4-D, atrazine, and lindane

Target

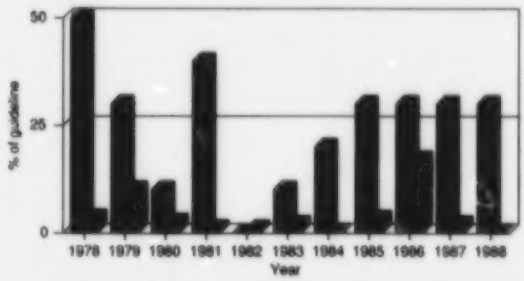
Canadian Water Quality Guidelines for Protection of Aquatic Life:
2,4-D — 4.0 micrograms* per litre in water
Atrazine — 2.0 micrograms* per litre in water
Lindane — 10.0 nanograms** per litre in water



Maximum concentrations of pesticides observed in the Bow River, Alberta, upstream of Calgary*



Maximum concentrations of pesticides observed in the Bow River, Alberta, >300 kilometres downstream of Calgary*



Maximum concentrations of pesticides observed in the Qu'Appelle River, near the Saskatchewan–Manitoba border**

2,4-D
Lindane

* Samples collected monthly.
** Samples collected quarterly.

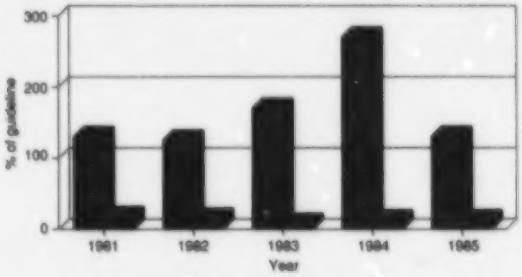
Source: Environment Canada, NAQUADAT database

Three pesticides of continued widespread use are the herbicides, 2,4-D and atrazine, and the insecticide, lindane. 2,4-D is a widely used herbicide for controlling broadleaf weeds. Atrazine is used primarily on corn in southern Ontario and Quebec. Lindane, an organochlorine insecticide, continues to be used in agricultural areas in the Prairies. Although it does not accumulate to appreciable levels in biota, it is relatively persistent and a major contaminant in precipitation samples.

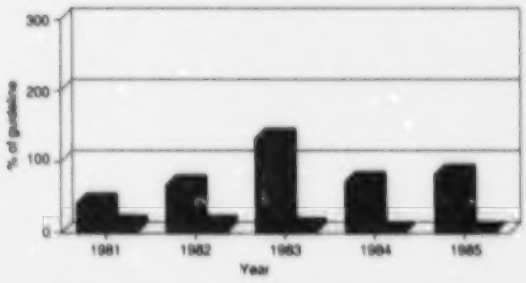
* Micrograms = 10^{-6} grams.
** Nanograms = 10^{-9} grams.

Indicator

Maximum observed concentrations of pesticides in water: 2,4-D, atrazine, and lindane *(continued)*



Average concentrations of pesticides observed in the Thames River, Ontario, near its mouth*



Average concentrations of pesticides observed in the Grand River, Ontario, near its mouth*

Atrazine
Lindane

* Samples collected weekly or biweekly.

Source: Frank and Logan 1988

Because of the very low levels at which all three compounds are found in the environment—they are often undetected—it is difficult to assess trends in their concentrations. Rather, the maximum or average observed concentration in a year is reported as a percentage of the guideline value for the protection of aquatic life. Sites where pesticide use is the highest have been selected, thereby representing the worst-case scenario for some major rivers in Canada.

Based on the sites selected, neither 2,4-D nor lindane exceeds its respective water quality guideline; therefore, no adverse effects are expected. Levels of atrazine in the two southern Ontario rivers exceed the guideline of 2.0 micrograms per litre, which suggests that there may be adverse effects on aquatic biota. Concentrations of atrazine, however, remain well below the Guidelines for Canadian Drinking Water Quality for atrazine (60 micrograms per litre).

Toxic Contaminants in the Freshwater Ecosystem

The problem of contaminants that persist in the environment emerged in the late 1970s as one of the major environmental issues confronting managers and scientists involved with the Great Lakes Basin, the largest freshwater ecosystem in the world. By 1987, 362 chemical substances had been positively identified as being present in the Great Lakes ecosystem, and the number grows as our ability to detect and analyze these substances improves. They find their way into the aquatic environment through different pathways: from industrial and municipal point sources, from a variety of non-point sources, such as urban and agricultural runoffs, groundwater discharges, and contaminated sediments, and through atmospheric depositions.

Organochlorine compounds are very persistent in the environment. They have the ability to bioconcentrate and bioaccumulate in the food chain, so that contaminants almost undetectable in the water may be concentrated hundreds to thousands of times in some Great Lakes fish and 10 000 times in the tissues of fish-eating birds.

Sixteen Great Lakes wildlife and fish species near the top of the food chain have had reproduction problems or a decline in populations at one time or other since 1950. In each case, high concentrations of contaminants were found in their tissues. Because wildlife and man share a common food resource, chronic exposure to persistent toxic chemicals in the Great Lakes Basin could also be harmful to human health.

The indicators for toxic contaminants in the freshwater ecosystem presented here are:

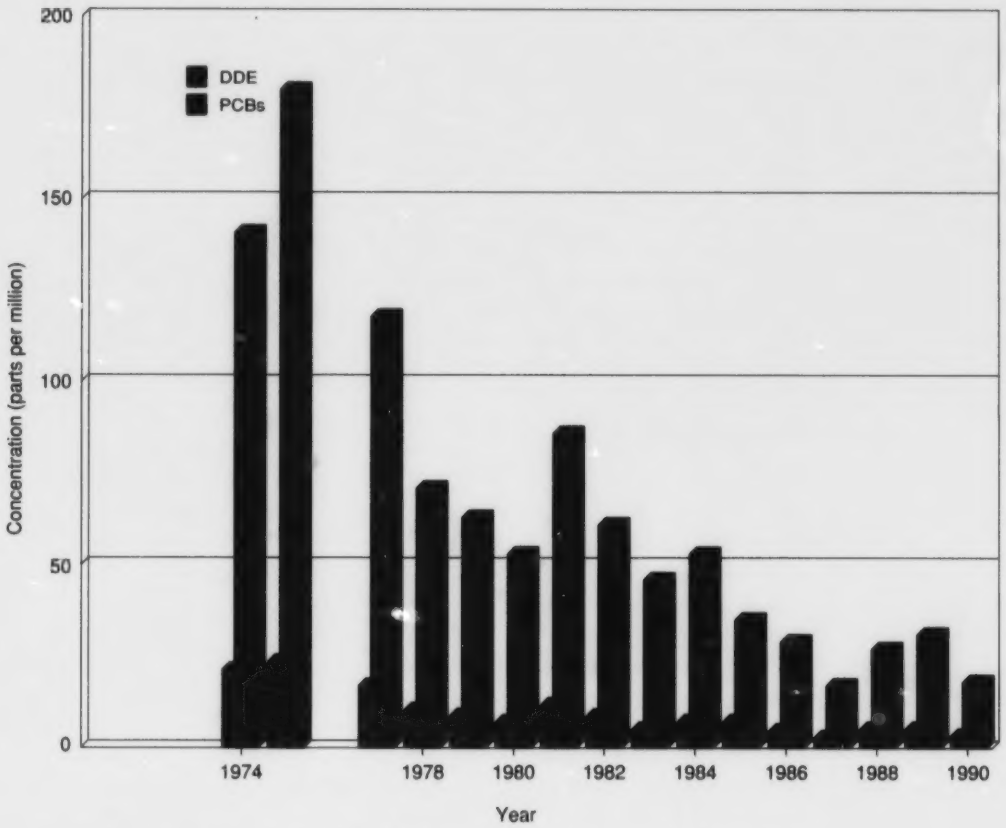
* Contaminant levels in Herring Gull eggs in the Great Lakes Basin: PCBs (polychlorinated biphenyls) and DDE (dichlorodiphenyldichloroethylene)
* Contaminant levels in Lake Trout, a sport fish from the Great Lakes Basin: PCBs and DDT (dichlorodiphenyltrichloroethane)

Indicator

Contaminant levels in Herring Gull eggs in the Great Lakes Basin: PCBs (polychlorinated biphenyls) and DDE (dichlorodiphenyldichloroethylene)

Long-term objectives

The Great Lakes Water Quality Agreement, revised and amended in 1978 and 1987, now states that discharge of toxic substances in toxic amounts should be prohibited, and discharge of any or all persistent toxic substances should be virtually eliminated.



DDE and PCBs in Herring Gull eggs: Snake Island, Lake Ontario

Source: Environment Canada, Canadian Wildlife Service, Ontario Region

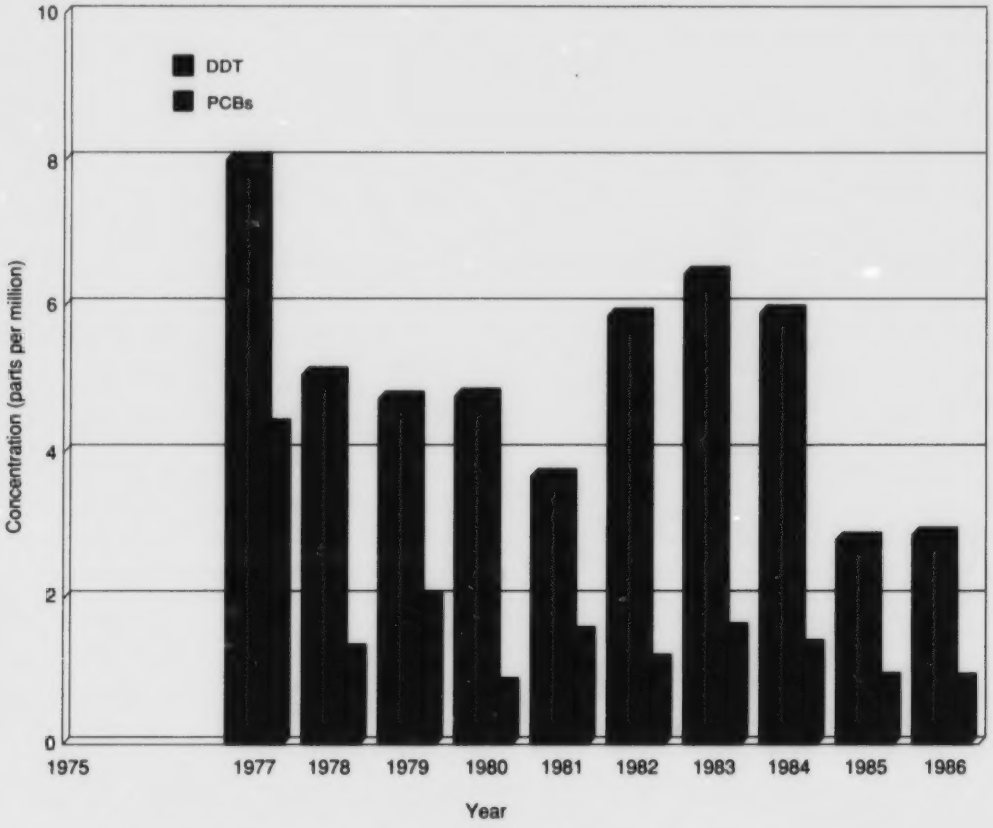
Herring Gulls are good indicators of lake-wide contamination within the Great Lakes Basin: they prey predominantly on fish, and they remain in the Great Lakes year-round. Herring Gull eggs have been collected from the same 13 colonies each year since 1974 and analyzed for a number of organochlorine compounds (e.g., PCBs, DDE, dieldrin, mirex, dioxins) and mercury. With the exception of dieldrin, organochlorine residues in Herring Gull eggs showed a marked decrease from 1974 to the early 1980s, as a result of better industrial practices and stringent regulations. Since then, the levels have remained essentially constant.

Of the five Great Lakes, Herring Gull eggs from Lake Ontario and Lake Michigan show the highest concentrations of contaminants during the entire monitoring period of 1974–1990; overall, Lake Ontario, represented here by the Snake Island colony, showed the greatest reduction of contaminants in Herring Gull eggs since 1974.

Indicator

Contaminant levels in Lake Trout, a sport fish from the Great Lakes Basin: PCBs (polychlorinated biphenyls) and DDT (dichlorodiphenyltrichloroethane)

Objectives Under the Great Lakes Water Quality Agreement (1987): PCBs—0.1 parts per million in whole fish; DDT—1.0 parts per million in whole fish.



Lake Ontario Lake Trout (aged 4+): Whole fish contaminant levels

Note: 1987–1989 data have been collected and analyzed, but data interpretation has not yet been completed, and therefore results are not available for publication.

Source: Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences

Lake Trout, a sport fish, is a predator at the top of the aquatic food web and is found in all the Great Lakes. It has been used to monitor the contaminant levels in fish since 1977. Furthermore, because the present evidence shows that, in the Great Lakes Basin, the dominant pathway of human exposure to toxic chemicals is through food consumption, the Lake Trout can be used as an early warning system to assess human health risks. Nevertheless, it should be kept in mind that humans are exposed to toxic chemicals from a variety of sources, and that little is known about the long-term human health effects from consuming Lake Trout from the Great Lakes.

Since 1977, uses of PCBs have been restricted under the Environmental Contaminants Act (now the Canadian Environmental Protection Act). Nevertheless, their levels, as shown above in the Lake Ontario Lake Trout, still exceed the Great Lakes Water Quality Agreement objective of 0.1 parts per million for whole fish. Since 1985, levels of DDT in Lake Ontario Lake Trout have remained essentially constant, near the Great Lakes Water Quality Agreement objective of 1.0 parts per million for whole fish.

Marine Environmental Quality

Canada's coastal zones, with their numerous islands, productive estuaries, and bays, support a diverse array of wildlife, including numerous species of seabirds and marine mammals. They also have important social, economic, and cultural value and are used for transportation, recreation, and tourism. The marine environment is also valued highly as a provider of harvestable resources, such as fish, shellfish, and marine plants.

Over the years, conflicts have arisen between human activities or uses that depend on the marine environment, such as fishing and recreation, and those that degrade it, such as waste disposal. Although the sea has the capacity to dilute and neutralize many types of wastes, pollutants in coastal waters can build up to harmful levels. Furthermore, the cumulative and synergistic effects and short- and long-term impacts of these contaminants on the marine environment are not completely known. For these reasons, it is important to monitor the health of the marine environment and how it is changing over time.

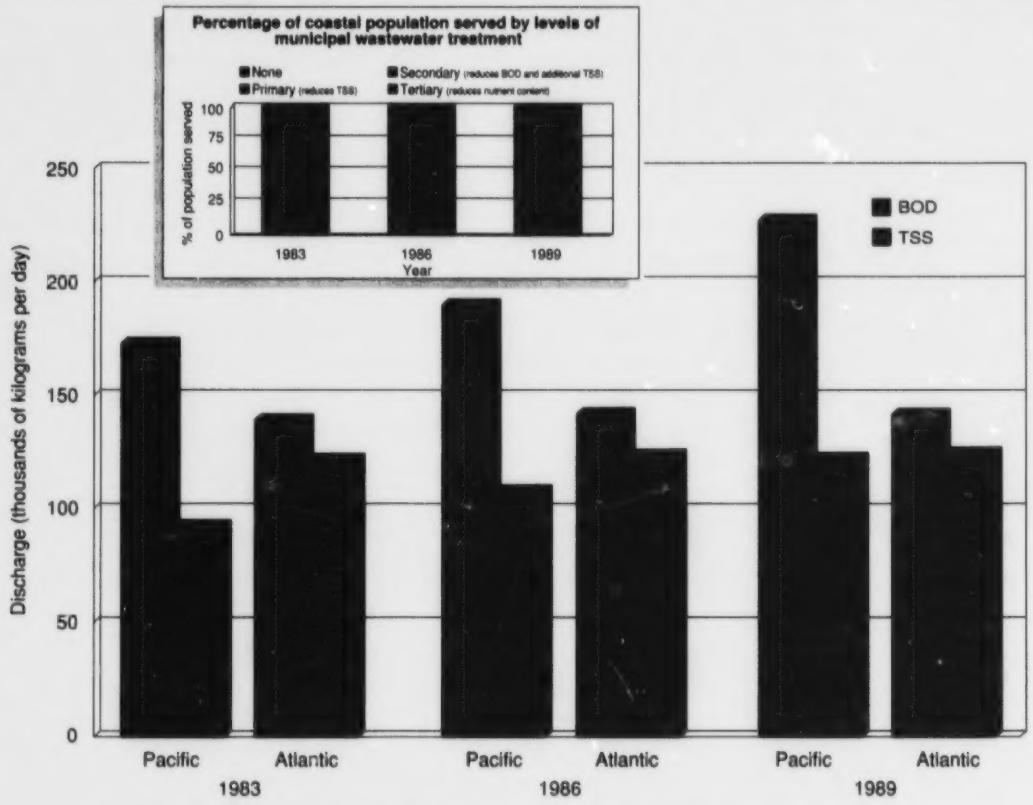
The indicators presented here for marine environmental quality are:

* Municipal discharges to coastal waters: TSS (total suspended solids) and BOD (biochemical oxygen demand)
* Pulp and paper mill discharges to coastal waters: TSS and BOD
* Volume of significant marine spills
* Area closed to shellfish harvesting
* Contaminant levels in seabird eggs: PCBs (polychlorinated biphenyls)
* Contaminant levels in seabird eggs: Dioxins and furans

Indicator

Municipal discharges to coastal waters: TSS (total suspended solids) and BOD (biochemical oxygen demand)

Target Not defined



Biochemical oxygen demand (BOD) and total suspended solids (TSS) discharged daily in coastal municipal wastewater effluents

Source: Environment Canada, MUNDAT and MUD databases

Municipal wastewater is an important source of contaminants in the marine environment. At sufficiently high concentrations, these contaminants can adversely affect marine life and economic activities such as shellfish harvesting.* Two common measures of municipal wastewater loadings to the marine environment are biochemical oxygen demand (BOD) and total suspended solids (TSS). BOD results from the decomposition of organic waste and can threaten aquatic life by reducing the oxygen content of the water. TSS, which include sand, grit, non-biodegradable materials, and human fecal matter, can alter benthic habitat and cause fecal coliform contamination.

BOD and TSS loadings on the Pacific coast increased between 1983 and 1989, largely as a result of increases in population and industrial activity. On the Atlantic coast, BOD levels and TSS discharges remained relatively constant. BOD levels were highest in 1989 on the Pacific coast, whereas loadings of TSS were similar on both coasts.

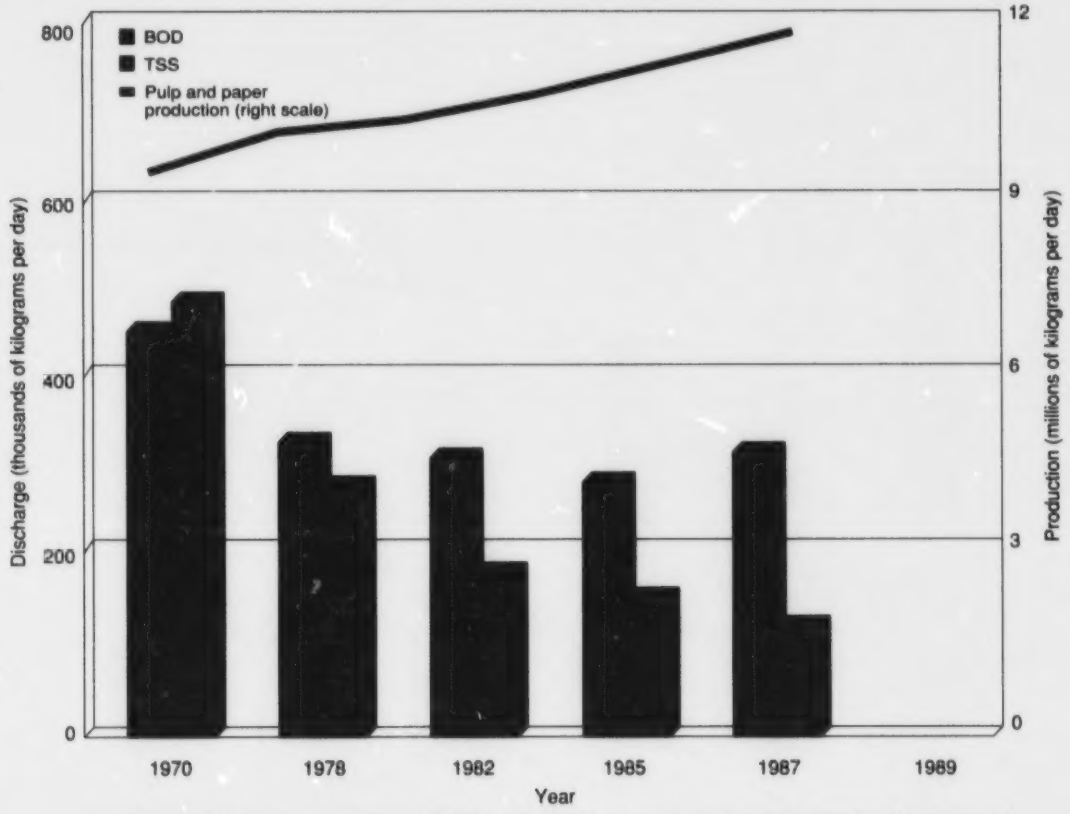
Many of the problems associated with municipal wastewater discharges can be controlled through wastewater treatment. In 1989, 47% of the coastal population in centres of over 1000 people was served by primary treatment, whereas about 38% received no treatment. Fifteen per cent of coastal populations received secondary treatment; very few communities used tertiary treatment for their wastewater. Few communities upgraded their waste treatment facilities in the period for which data are available —1983–1989.

*Fecal coliforms, a group of bacteria found in sewage, are implicated in about half of shellfish area closures on the Pacific and Atlantic coasts.

Indicator

Pulp and paper mill discharges to coastal waters: TSS (total suspended solids) and BOD (biochemical oxygen demand)

Target To be defined in the 1991 federal pulp and paper regulations



Biochemical oxygen demand (BOD) and total suspended solids (TSS) discharged daily from pulp and paper mills to Pacific coastal waters

Source: Environment Canada, Industrial Programs Branch

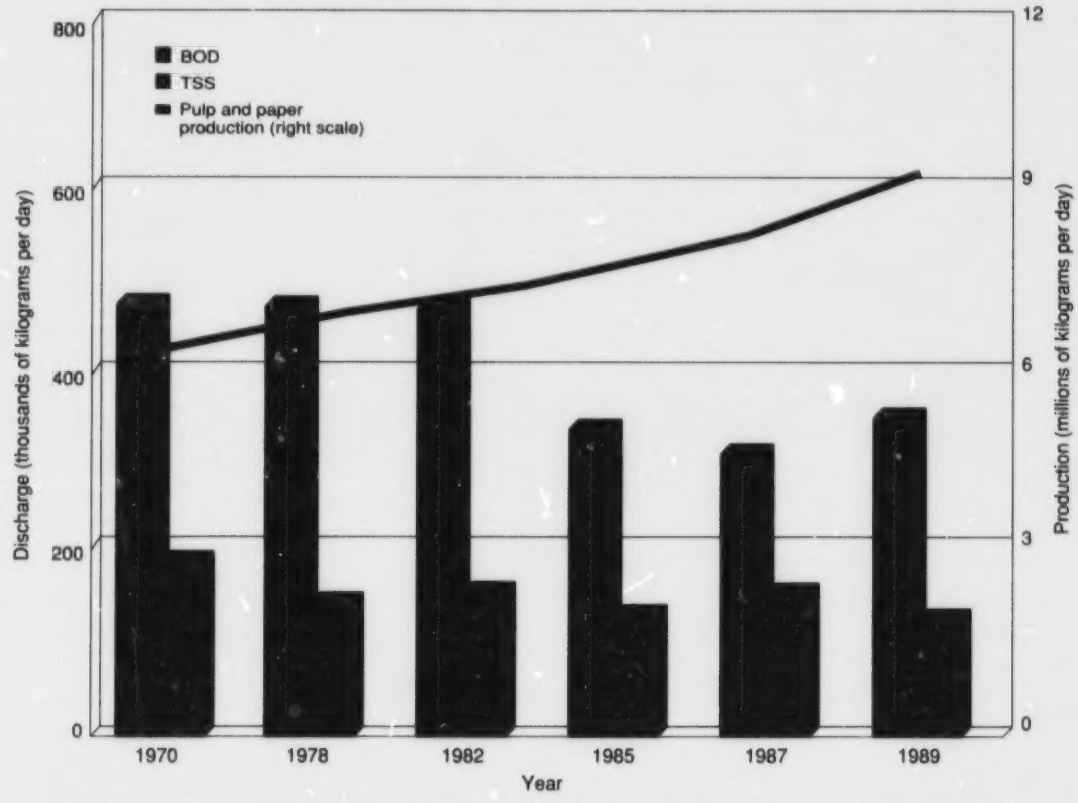
The production of pulp and paper generates large quantities of waste. Two common measures of pulp and paper mill loadings to the marine environment are total suspended solids (TSS) and biochemical oxygen demand (BOD). TSS, which include fibre, bark, and mill residues, affect benthic life by smothering habitat. BOD results from the decomposition of organic waste and can threaten aquatic life by lowering the oxygen content of the water.*

On the Pacific coast, pulp and paper production per day increased about 23% between 1970 and 1987. BOD levels and TSS loadings into the marine environment from coastal pulp and paper mills declined over the same period. This decline can be attributed to the installation of primary treatment systems at certain coastal mills.

* Other types of contaminants originating from pulp and paper mills, including those that are toxic to wildlife, such as dioxins and furans, are not measured by TSS or BOD. Because these contaminants have not been monitored on a regular basis, it is not possible to identify absolute trends in their release at this time.

Indicator

Pulp and paper mill discharges to coastal waters: TSS (total suspended solids) and BOD (biochemical oxygen demand) *(continued)*



Biochemical oxygen demand (BOD) and total suspended solids (TSS) discharged daily from pulp and paper mills to Atlantic coastal waters

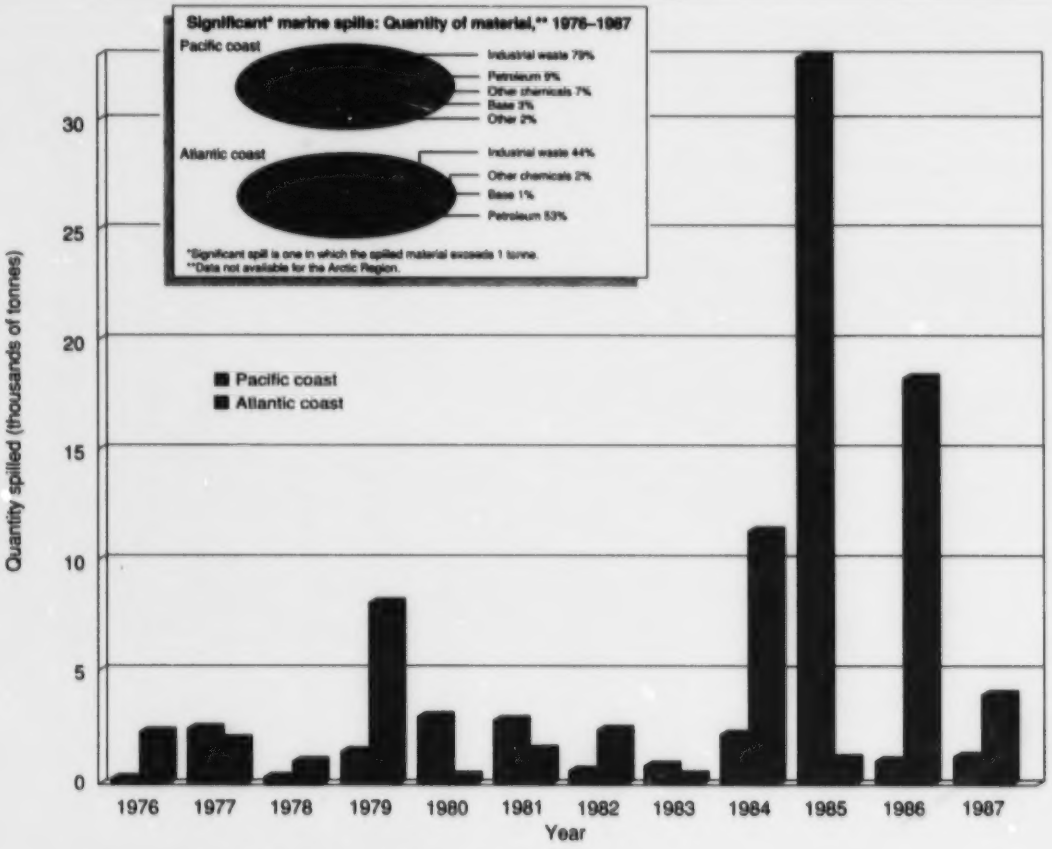
Source: Environment Canada, Industrial Programs Branch

On the Atlantic coast, pulp and paper production per day was lower than that on the Pacific coast and increased about 35% between 1982 and 1987. TSS loadings remained at a more constant and relatively lower level than on the Pacific coast between 1982 and 1987, whereas BOD levels declined over the same period. This decrease in BOD is the result of a transition from chemical to pure mechanical pulping methods in certain pulp and paper mills. In 1987, TSS loadings and BOD levels were similar on both coasts.

Despite the progress achieved in reducing BOD levels and TSS discharges from pulp and paper mills, substantial amounts of TSS and organic waste continue to be released into the marine environment. Current federal effluent regulations that control these wastes apply only to mills built, expanded, or altered after 1971. New federal pulp and paper regulations, to be enacted in 1991, will apply to all pulp and paper mills in Canada and call for significantly lower discharges of TSS and BOD.

Indicator
Volume of significant marine spills

Target Not defined



Significant* marine spills, 1976–1987**

* Significant spill is one in which the spilled material exceeds 1 tonne.

** Data not available for the Arctic region.

Source: Environment Canada, NATES database

Marine spills can have profound effects on marine ecosystems and on resource-based industries, such as fishing. In the period 1976–1987, the volume of material spilled on the Atlantic and Pacific coasts fluctuated widely from year to year; no significant trend upward or downward is evident.*

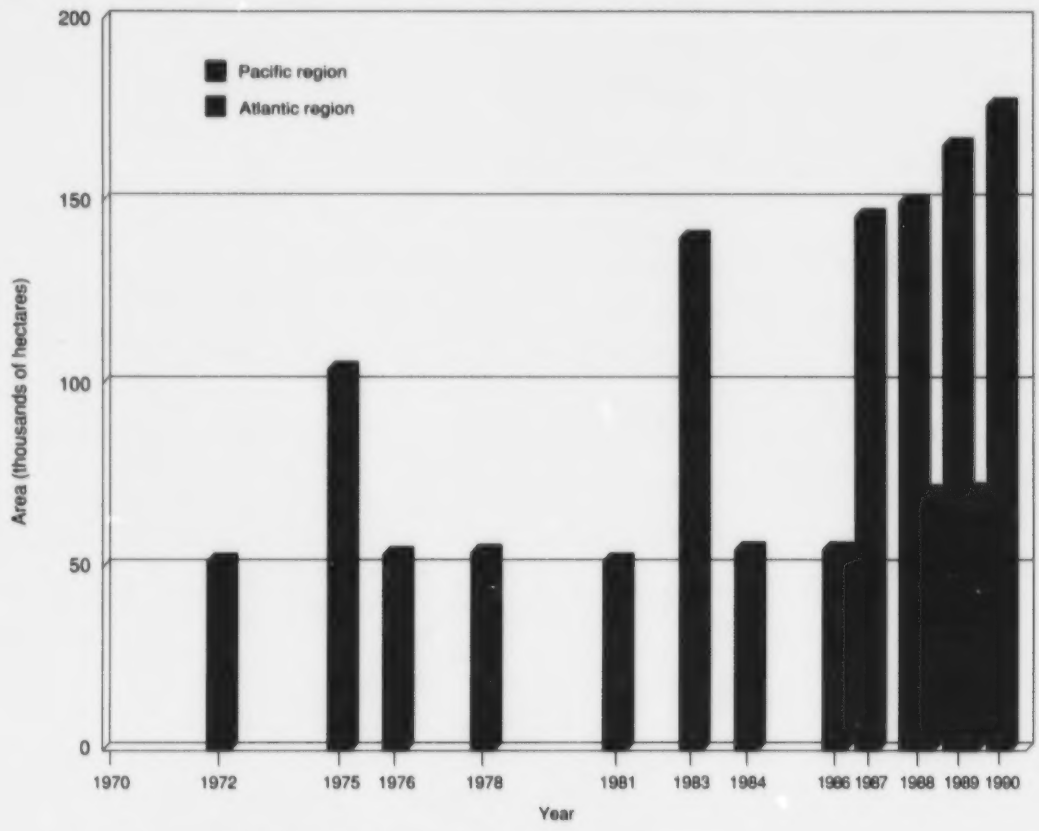
On the Atlantic coast, petroleum and industrial waste spills accounted for about 97% of the material spilled between 1976 and 1987 (about 52 000 tonnes). On the Pacific coast, industrial waste made up the largest quantity (79%) of spilled material (about 48 000 tonnes). From 1976 to 1987, 171 significant (greater than 1 tonne) marine spills occurred in waters off Canada's Atlantic coast, and 180 spills occurred in the Pacific marine environment. Petroleum spills made up the largest number of reported spills on both the Pacific (67%) and Atlantic (88%) coasts.

In an effort to prevent environmental damage from marine spills, research aimed at establishing coastal response centres, reducing impacts, and increasing efficiency of cleanup operations has been ongoing in Canada.

*It is difficult to gauge the significance (in terms of identifying a trend) of the large volumes spilled in recent years; they show wide fluctuation from year to year and are the result of one or two large-volume spills—frequencies too small to be statistically significant. The large volume spilled on the Pacific coast in 1985, for example, results from two industrial waste spills of 22 000 and 10 000 tonnes.

Indicator
Area closed to shellfish harvesting

Target Not defined



Area closed to shellfish harvesting, 1972–1990

Note: Area closed due to fecal coliform contamination.

Source: Environment Canada, Environmental Protection, Pacific and Yukon, and Atlantic; Menon 1988

The area closed to shellfish harvesting is an indicator of contamination problems in coastal waters. Closures are linked mainly to contamination from human and animal wastes and runoff from agriculture and rural areas, as well as other diverse pollution sources. Shellfish harvesting closures also represent a loss of potential economic benefits. The area closed to shellfish harvesting on the Pacific and Atlantic coasts has increased steadily since 1972. This is the result of increased surveillance effort and identification of new areas that exceed fecal contamination standards.* On the Atlantic coast,** just over one-third (37%, or just over 165 000 hectares) of the area classified for direct harvesting of shellfish was closed in 1989 (area closed increased by almost 70% from 1975 to 1990). On the Pacific coast, 71 000 hectares were closed to shellfish harvesting in 1989 (area closed increased by almost 40% from 1972 to 1989).

Nationally, municipal wastewater discharges are implicated in about half of the shellfish area closures, an indication that untreated or poorly treated municipal waste discharges continue to affect the quality of coastal waters. Shellfish harvesting closures are designed to protect public health from pollution effects. It should be noted that many areas that have limited or no shellfish potential are included in these closures.

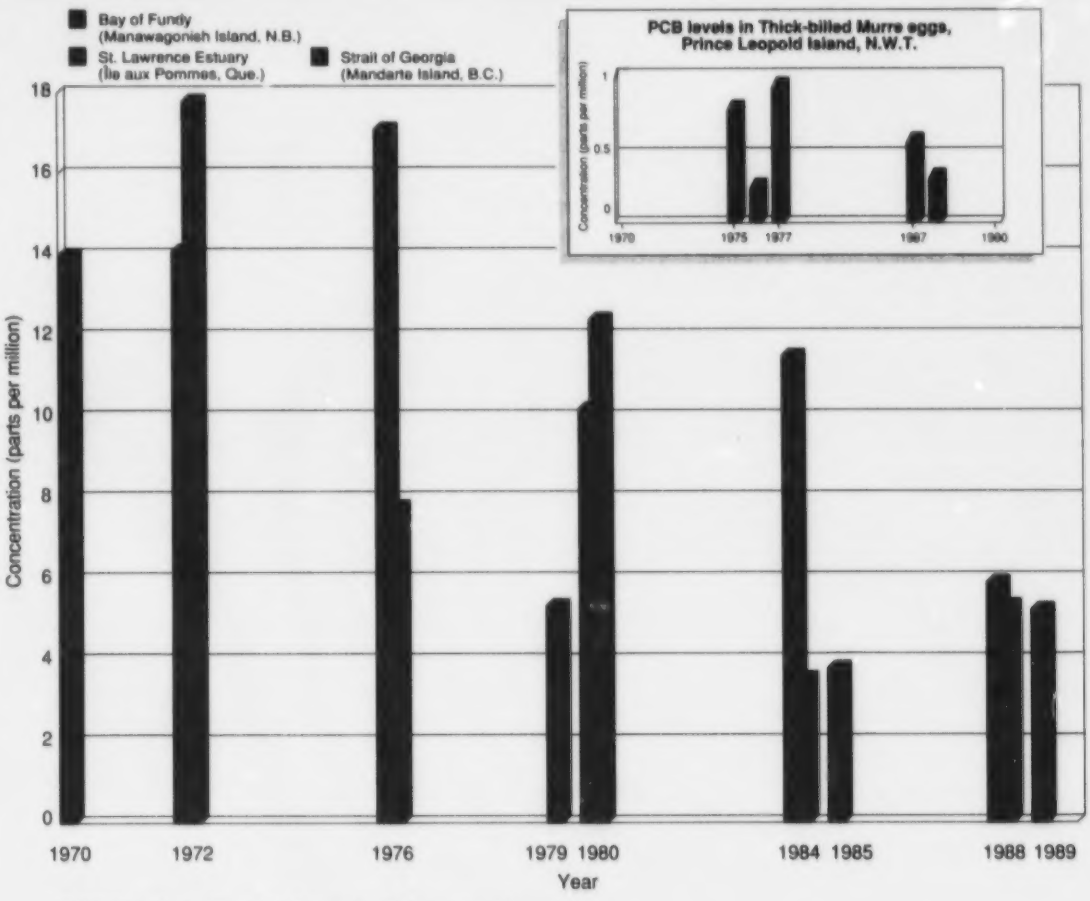
*Shellfish-growing waters are classified as closed or contaminated if the fecal coliform (a group of bacteria found in sewage) density in the water exceeds a level above which there is risk to human health.

** Data are not available for the Quebec region.

Indicator

Contaminant levels in seabird eggs: PCBs (polychlorinated biphenyls)

Target Not defined



PCB levels in Doubled-crested Cormorant eggs

Source: Environment Canada, Canadian Wildlife Service, Wildlife Toxicology and Surveys Branch

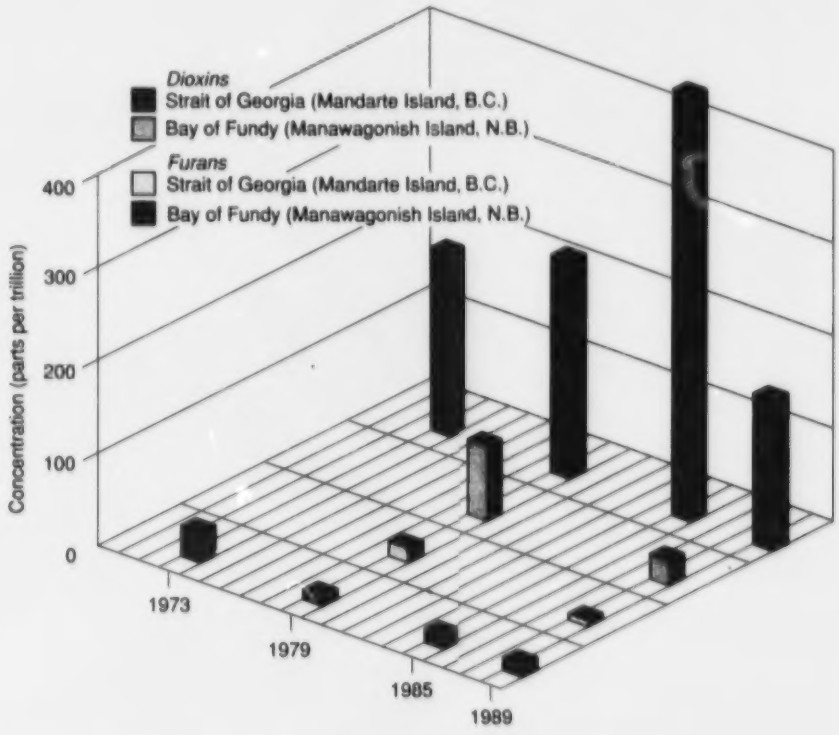
Seabirds accumulate contaminants such as synthetic organochlorine compounds in their tissues and thus act as indicators of the bioavailability of persistent contaminants in the marine environment. The Double-crested Cormorant, an inshore feeder, serves as an indicator of the presence of organochlorine contaminants in the Pacific and Atlantic coastal zones. The Thick-billed Murre, an offshore feeder, serves as an indicator of these contaminants in the Arctic Ocean. The levels of polychlorinated biphenyls (PCBs) — a type of organochlorine compound — in the eggs of these two species of seabirds are presented here.

Since the early 1970s, levels of PCBs in eggs of Double-crested Cormorants have declined at the sampling locations in the Bay of Fundy, St. Lawrence estuary, and Strait of Georgia, and concentrations are now similar at all three sites. PCB levels in the eggs of Thick-billed Murres from the high Arctic appear to have declined slightly between the mid-1970s and the late 1980s and are about 10 times lower than those in the cormorants. Levels of total PCBs at these four sites are currently below concentrations known to threaten the health of seabirds.

After achieving widespread use in the 1960s, PCB levels in the marine ecosystem have generally declined in response to voluntary and regulatory actions in Canada and other countries. Measures are currently in place to phase out PCBs in use in sensitive locations such as schools and hospitals.

Indicator
Contaminant levels in seabird eggs: Dioxins and furans

Target Not defined



Dioxin and furan levels in Double-crested Cormorant eggs

Source: Environment Canada, Canadian Wildlife Service, Wildlife, Toxcology and Surveys Branch

Dioxins and furans are extremely toxic compounds that readily accumulate in the fatty tissues of organisms. Sources include chlorophenols used in the lumber industry, chlorine bleaching of wood pulp, certain chlorine-containing herbicides, and incineration of chlorine-containing materials.

Levels of total dioxins, including the most toxic dioxin (2,3,7,8-tetrachlorodibenzodioxin, or TCDD), in eggs of cormorants in the Strait of Georgia increased between 1973 and 1985. In 1989, total dioxin levels, but not TCDD levels, were much reduced. The total dioxin trends in British Columbia parallel the use patterns of chlorophenols in treatment of lumber. In the Bay of Fundy, total dioxin levels at the sampling location were slightly lower in 1988 than in 1979. Total furan levels in the eggs of the cormorant populations in the Bay of Fundy declined between 1979 and 1988, whereas concentrations at the sampling location in the Strait of Georgia show little change since 1979.

In the late 1980s, both dioxin and furan concentrations in eggs of Double-crested Cormorants were higher in the Strait of Georgia than along the Atlantic coast or in the Great Lakes. Although the biological significance of the observed levels to cormorant populations is not yet known, similar levels of these compounds in the eggs of Great Blue Herons in the Strait of Georgia are suspected of causing reproductive problems.

Releases of dioxins and furans are not regulated in Canada. However, regulation of one major source will be enacted under new federal pulp and paper mill regulations in 1991.

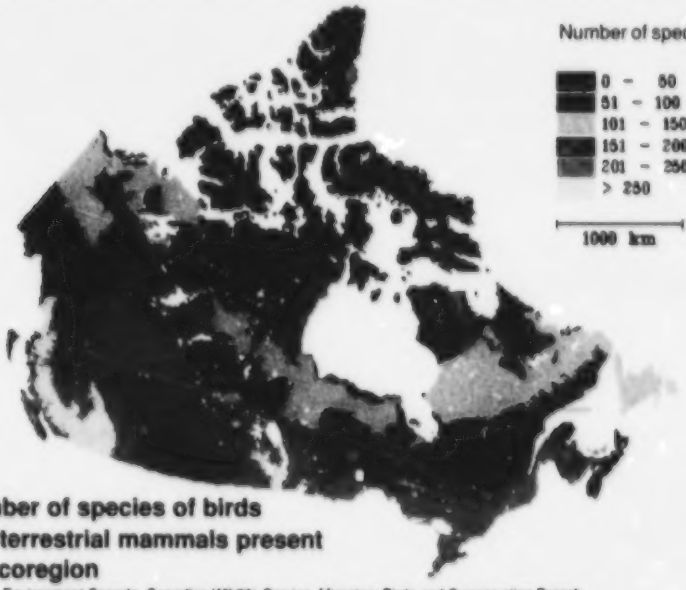
Biota (Living Organisms)

Biological Diversity at Risk

Biological diversity or "biodiversity" means the variety of life in all its forms. It encompasses all species of plants, animals, and microorganisms, as well as the ecosystems and ecological processes of which they are part.

In Canada, as elsewhere in the world, biological diversity is at risk: the natural rates of extinction or disappearance of species have been accelerated by increased human activity and associated environmental impacts. Between the 1600s and the 1900s, species disappeared from the Earth at an estimated rate of one every 4 years; today, the global loss is estimated at one to five species daily.

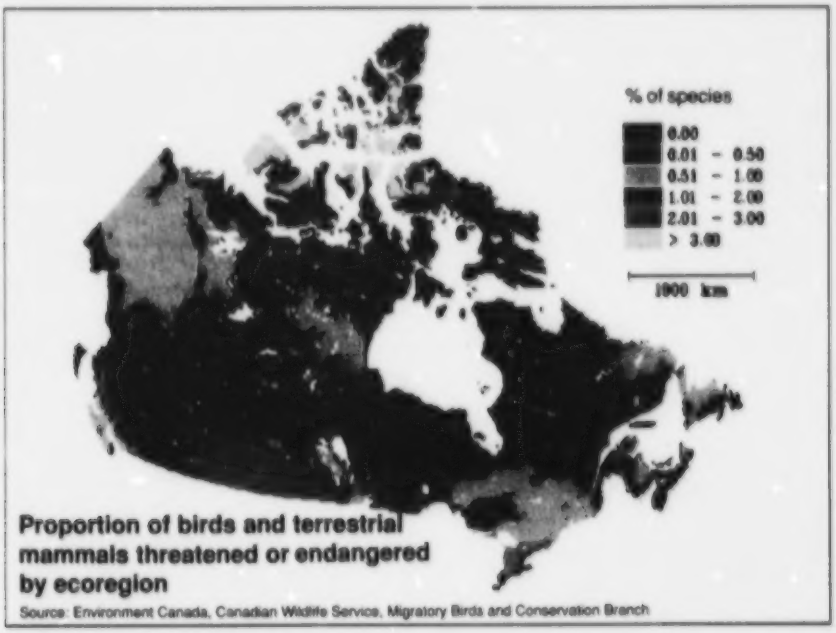
Canada holds a rich diversity of wildlife species and habitats. Nevertheless, our present knowledge of our native biological resources is incomplete and inadequate to ensure their survival. Although almost all the Canadian plants and larger animals have been identified, fewer than 50% of Canadian species in some groups, such as insects and fungi, have been named and classified. Even less is known about the variety of genes needed within a species so that it can resist diseases and adapt to climate change and other environmental stress throughout its range.



Number of species of birds and terrestrial mammals present by ecoregion

Source: Environment Canada, Canadian Wildlife Service, Migratory Birds and Conservation Branch

This map represents the natural pattern of Canadian biological diversity, based on ecological regions and historical distribution maps for over 500 species of birds and terrestrial mammals. In general, species richness (the number of species present in an ecoregion) declines towards the northern parts of Canada. The largest numbers of species are in southern Ontario and Quebec, the Prairies, and mountainous southern British Columbia. This corresponds to similar natural patterns in habitat diversity.



Proportion of birds and terrestrial mammals threatened or endangered by ecoregion

Source: Environment Canada, Canadian Wildlife Service, Migratory Birds and Conservation Branch

This map represents the relative stress on biodiversity in different parts of Canada by showing the proportion of birds and terrestrial mammals that are threatened or endangered in each ecoregion. In general, biological diversity is under most pressure and decline in the highly disturbed habitats of southern Canada, which are impacted by the conversion of natural landscapes for agricultural and urban uses and by modern agricultural practices, and in the Arctic, where the smaller total number of species makes any change in species more important.

When interpreting both maps, one should keep in mind that, in future, invertebrates, plants, fish, and marine mammals should also be included to reflect the natural biological diversity of Canada.

The indicator presented here for biological diversity at risk is:

* Wildlife species at risk

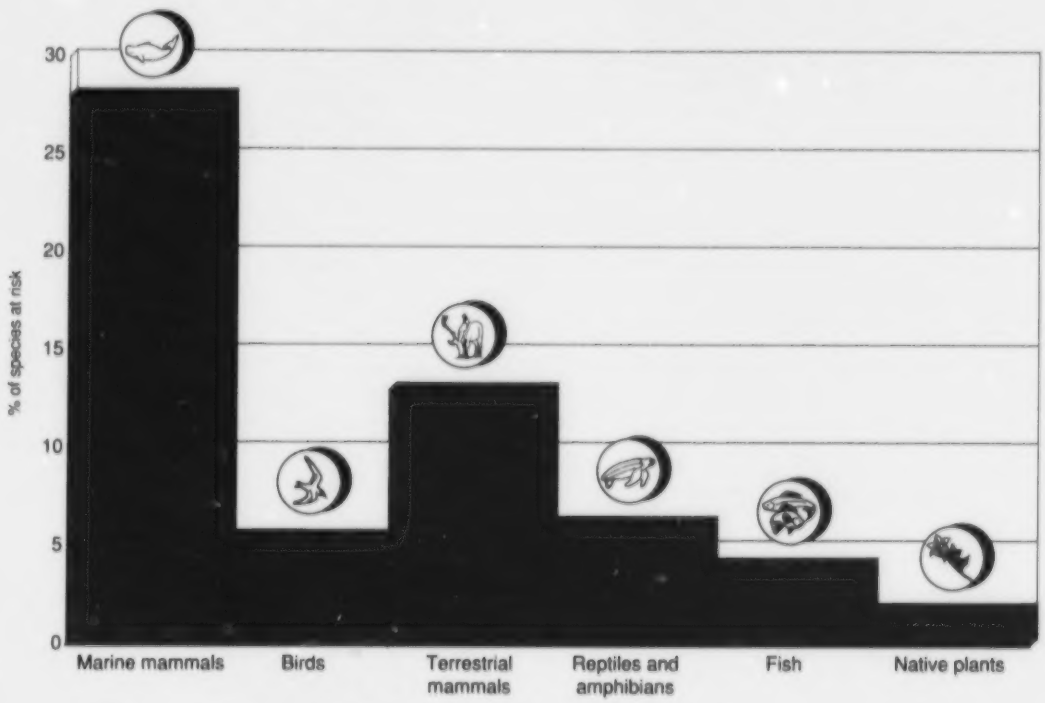
Indicator
Wildlife species at risk

Mid-term objective

Under the National Program of Recovery of Nationally Endangered Wildlife, all the recovery teams and the recovery plans for the currently identified endangered birds and terrestrial mammals will be established by 1992.

Targets

Each recovery plan will have specific rehabilitation targets. For example, for the Whooping Crane, rehabilitation targets are as follows: in Canada, by the year 2000, 40 breeding wild pairs in Wood Buffalo National Park; at the continental level, by the year 2010: in addition to the Canadian target, 1–2 other wild groups of 25 breeding pairs and 2–3 captive groups of 5–15 breeding pairs.



Wildlife species at risk, as reported by COSEWIC* in 1990

* Committee on the Status of Endangered Wildlife in Canada.

Source: Environment Canada, Canadian Wildlife Service

This figure presents the proportion of wildlife species of marine and terrestrial mammals, birds, reptiles and amphibians, fish, and plants that are currently identified at risk — Endangered or Threatened or Vulnerable — as reported in 1990 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Since its formation in 1978, COSEWIC has evaluated over 240 species and has re-evaluated 17 species at risk; only three species have shown some improvement. As of 1990, COSEWIC has officially listed 39 species as Endangered, 47 species as Threatened, 89 species as Vulnerable, and 17 species as Extinct or Extirpated (no longer found in Canada). When interpreting this information, it should be kept in mind that not all species have been identified in Canada, and that the COSEWIC lists provide information only on species that have been reported on — at least 150 species are awaiting a status report as of 1990.

State of Wildlife

Changes in populations of wildlife species are increasingly being used to assess trends in available habitat. In Canada, wildlife habitats are vanishing at a rapid pace. Wetlands are essential to a broad range of wildlife species in Canada; however, they have been drained or filled for agricultural purposes, as well as for urban and industrial uses, since the beginning of European settlement. Already 20 million hectares of marshes and other wetlands have been destroyed.

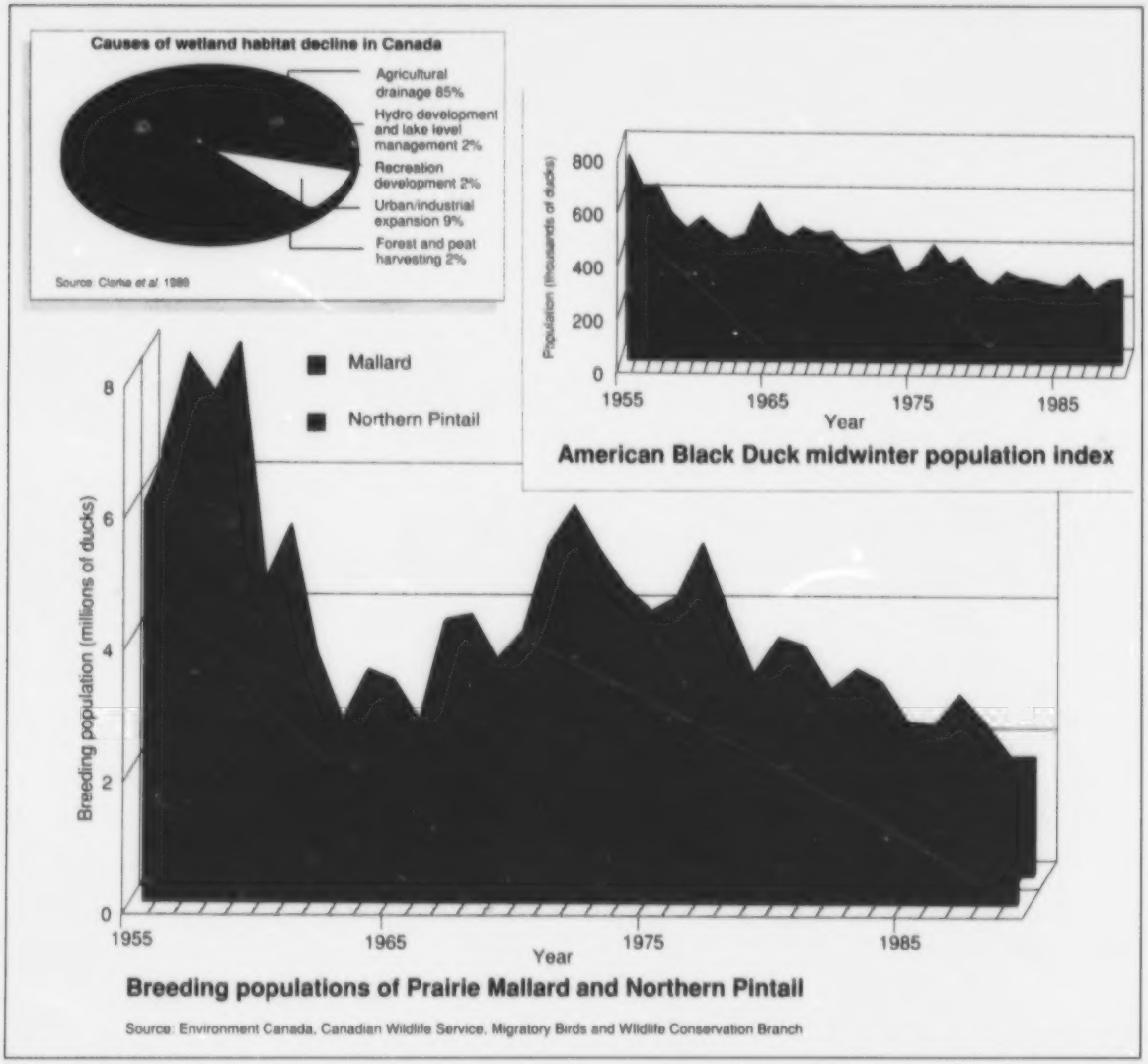
The disappearance of wetlands is particularly serious for the waterfowl populations that depend on them as breeding and wintering habitats. This is most evident in the Prairies of Canada, where approximately 60% of the continental waterfowl populations breed. Populations of Mallards, Northern Pintails, and American Black Ducks, among the most abundant and widespread species of waterfowl breeding in North America, have declined over the last 30 years. At present, waterfowl is the group of wildlife species for which significant trends have been documented. In the future, to better represent the state of wildlife populations, other species, such as migratory non-game birds and game mammals, should be used, as data become available.

The indicator presented for the state of wildlife is:

* Levels of migratory game bird populations

Indicator
Levels of migratory game bird populations

Targets Under the North American Waterfowl Management Plan, by the year 2000:
(i) restoration of waterfowl populations at their 1970s levels: a fall flight of 100 million ducks; a breeding population of 17 million for Mallard and 5.5 million for Northern Pintail, and a midwinter population of 385 000 for American Black Ducks; and
(ii) conservation and enhancement of 1.8 million hectares of waterfowl habitat across Canada.



Since 1955, populations of Mallards and Northern Pintails have been declining, paralleled by an increased degradation of waterfowl breeding habitat. Prairie wetlands (potholes) provide important breeding habitat for half of the continent's ducks. At the same time, these wetlands are part of a rich grain and pasture agricultural landscape that is increasingly being drained and filled by farmers seeking more farmland for crop production.

In eastern Canada, the American Black Duck population has been declining steadily in its western range over the last 30 years. The decline has been generally attributed to harvest pressures, habitat competition with other species, hybridization with Mallards, and loss and degradation of their wintering and breeding habitat. The use of the midwinter count for estimating American Black Duck populations is limited mainly because it is not known what proportion of the entire winter population is counted in any one year.

Land

Protected Areas

Over the years, concern in Canada and globally has increased with regard to overexploitation of the world's ecosystems. This concern was brought to the forefront with the release of the report *Our Common Future* by the World Commission on Environment and Development, which advocated that, on a global scale, we should triple the representative samples of ecosystems under protected status.

In Canada, the issue of protected areas relates to such concerns as the potential loss of old-growth forest to logging, conversion of native ecosystems to urban uses, the degradation of wildlife habitat, the maintenance of ecosystem biodiversity, and increased demands for national and provincial parks.

Currently, protected areas, which include areas legally set aside for conservation objectives, occupy about 7% of Canada's land area. Several initiatives are under way to develop national plans so that targets of 12% will be achieved not only in the sense of areas under protection but in the sense of representative samples of ecosystems.

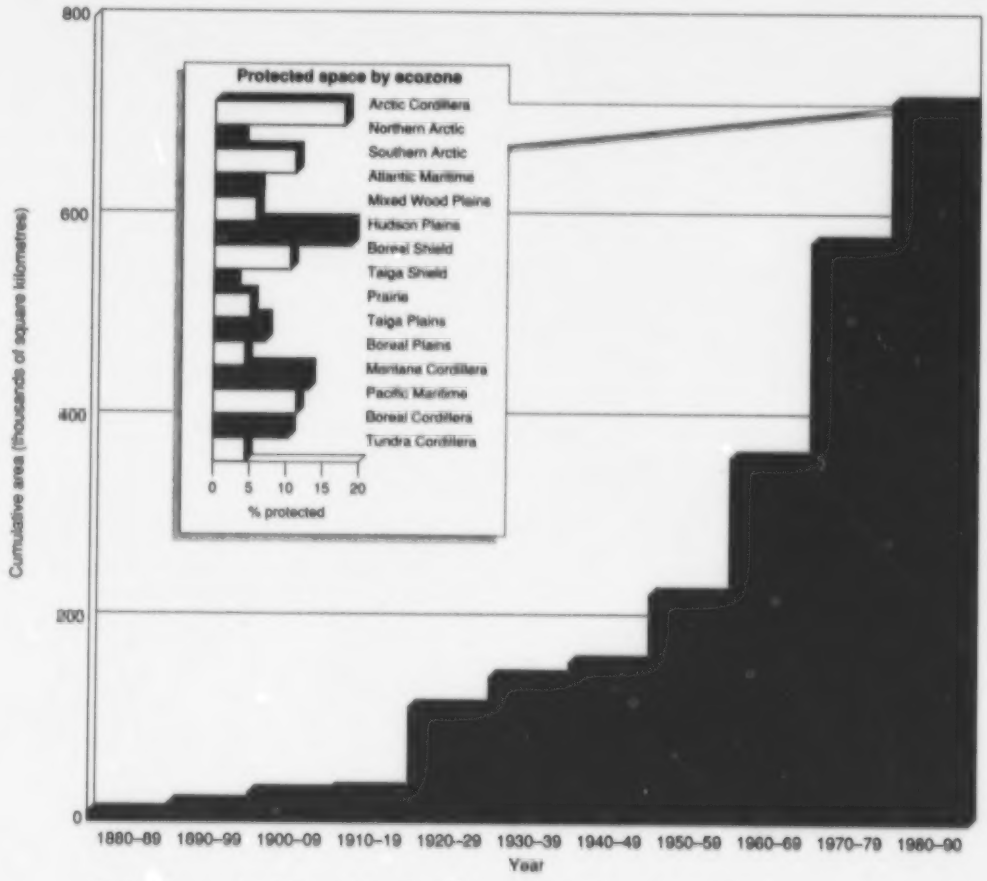
The indicator presented for protected areas is:

* Land under protected status

Indicator
Land under protected status

Targets

(1) Five new national parks and 3 new national marine parks by 1996; and 3 new national marine parks and agreements for 13 more national parks by the year 2000.
(2) Canada's long-term goal is to set aside as protected space 12% of the country.



Federal, provincial, and territorial protected areas in Canada

Source: Environment Canada, State of the Environment Reporting

This figure shows the trend in the procurement of land for conservation since the late 1800s. To date, approximately 720 000 square kilometres of Canada's federal, territorial, and provincial lands fall under the general definition of "conservation area." Lands that are held for conservation and preservation but are under private control are not included; a database currently being compiled suggests that these areas cover at least 70 000 square kilometres.

Since the 1960s, protected areas have doubled, from approximately 350 000 to over 700 000 square kilometres. These protected areas include 34 national parks, covering 180 000 square kilometres. Currently, of the 15 major terrestrial ecological zones that comprise Canada, both the Hudson Plains and the Arctic Cordillera have well over 12% of their land area protected.

Urbanization

The majority of Canada's population resides within urban areas that are in close proximity to some of the country's best lands for renewable resource production. This juxtaposition results in serious land-use conflicts, exemplified in some regions by the irretrievable loss of high-quality forest land, wildlife habitat, and farmland.

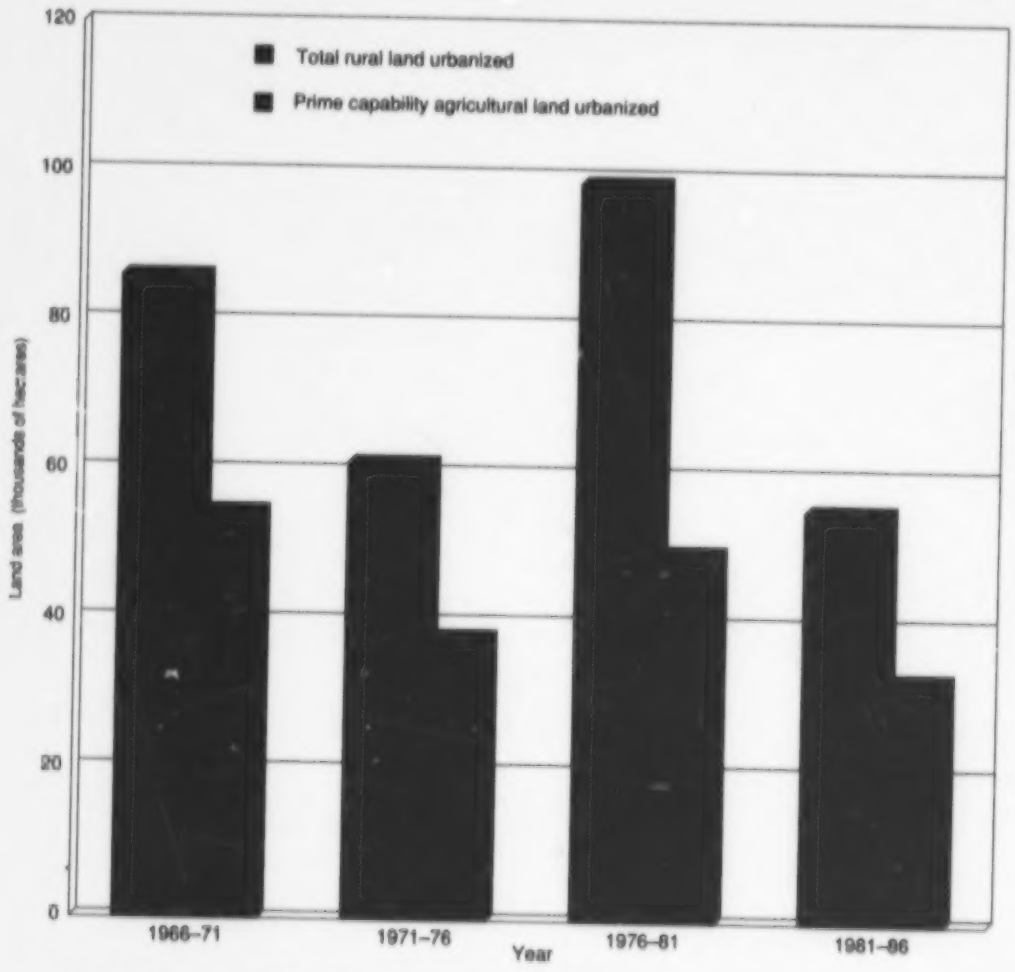
The loss of prime agricultural land near urban areas has been a significant land-use issue in Canada over the last several decades. The Canada Land Inventory (CLI) indicates that only 11% of the country's total land area is capable of agricultural production, and less than 5% is prime capability (CLI classes 1–3) agricultural land, capable of producing a wide range of crops. Of this 5%, more than half is located in close proximity to urban areas, and, consequently, much urban expansion is occurring on prime agricultural land. Once agricultural land has been converted to urban uses, it is essentially no longer available for food production. The rapid urbanization of agricultural land caused some jurisdictions to introduce agricultural land reserve policies and legislation during the 1970s. The rate and extent of loss of prime agricultural land to urbanization are measures of the depletion of Canada's high-quality agricultural resource base.

The indicator presented for determining the trend in urbanization of agricultural land is:

* Rural to urban land conversion

Indicator
Rural to urban land conversion

Target Not defined



Conversion of rural land and prime capability agricultural land (CLI classes 1–3) to urbanization, 1966–1986

Source: Warren *et al.* 1989

Between 1966 and 1986, urban conversion of rural land was monitored at 5-year intervals in 70 Canadian urban areas with populations of more than 25 000. During this 20-year period, 301 440 hectares of rural land, an area half the size of Prince Edward Island, were converted to urban and urban-related uses. Land with prime capability for agricultural production accounted for approximately 58% of the converted lands. More than half of the rural land converted to urban uses in each of the four monitoring periods was prime agricultural land.

Urban expansion appears to fluctuate with economic conditions, such that larger amounts of rural land are urbanized during periods of prosperity than during periods of slower economic growth. Between 1966 and 1986, the area of rural land converted to urban uses peaked during 1976–1981, a relatively prosperous economic period. The subsequent decline in rural land conversion in the 1981–1986 period reflects the economic recession of the early 1980s.

Solid Waste Management

Solid waste management is a pressing problem in Canada. Jurisdictions throughout the country are facing critical shortages in landfill space, and the economic costs of waste disposal are increasing rapidly. In addition, there is a growing awareness of the environmental costs of traditional waste disposal practices.

It is estimated that Canadians generate about 16 million tonnes of municipal solid waste each year. On a per capita basis, this represents about 1.7 kilograms per person per day, one of the largest per capita generation rates in the world. This relatively large generation rate is a result of a number of factors, including our high standard of living, waste management practices, our resource-based economy, and a general lack of awareness by the general public of the consequences of excessive waste disposal.

There are, however, some positive trends occurring. Communities across Canada are introducing a variety of programs to reduce waste volumes; these include recycling, composting, incineration that produces energy from waste, and programs that encourage reuse over disposal. The serious nature of Canada's waste management problems has been recognized by the Canadian Council of Ministers of the Environment, which established, in 1989, a national goal of 50% reduction in waste generation by the year 2000.

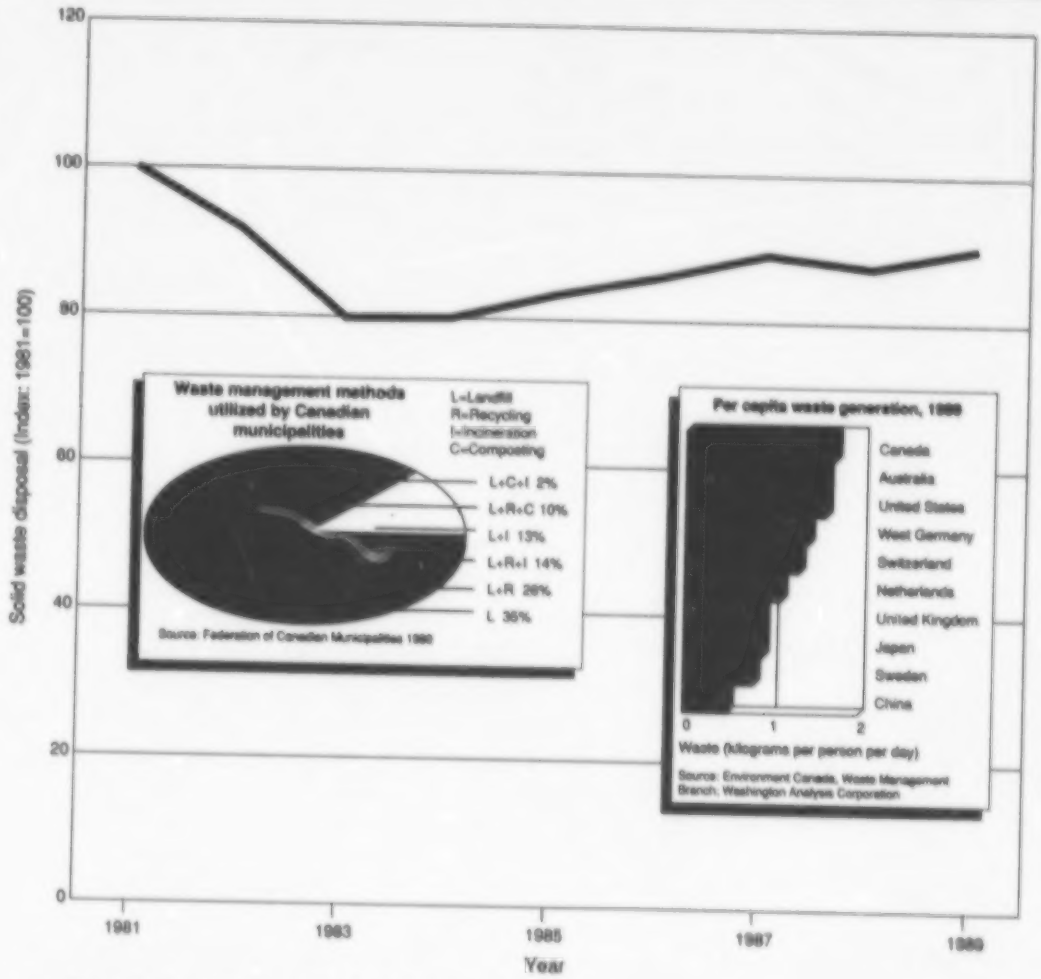
From an indicator perspective, it is difficult to gather information on solid waste. Because waste management has come into prominence as an issue only in the last few years, there are few accurate historical data on municipal solid waste. In addition, the large number of landfill sites has made it difficult to establish comprehensive monitoring systems to gather hard data on waste generation and composition. Other barriers, such as municipal budget constraints and a lack of data collection systems in some communities, make the development of national-level solid waste indicators problematic.

The indicator presented for solid waste management in Canada is:

* Municipal solid waste disposal trends

Indicator
Municipal solid waste disposal trends

Target Canadian Council of Ministers of the Environment: 50% reduction in national waste generation by the year 2000.



Trends in municipal solid waste disposal

Note: The graph does not include waste disposed at private landfill sites.

Source: Data are based on disposal statistics supplied by the following Canadian cities: Halifax, Ottawa, Toronto, Winnipeg, Regina, Calgary, and Edmonton

The graph portrays an index representing aggregate trends in waste disposal for seven Canadian cities. In the cities represented, there was an overall decrease (approximately 10%) in municipal solid waste disposal during the last decade. This decline is a result of a number of factors, including lower economic activity in some municipalities and the adoption of resource-saving waste management practices, such as recycling and composting.

The first inset shows the various types of waste management options used by Canadian communities. The data, gathered by the Federation of Canadian Municipalities, indicate the percentage of municipalities that are recycling and composting. Canada's per capita waste generation in relation to other countries is portrayed in the second inset.

Natural Economic Resources

Forestry

One of the major concerns in the forestry sector over the years has been the gradual buildup over time of forest land considered to be "not sufficiently restocked" — land harvested for its timber but not successfully regenerated to levels that would sustain new forest growth equivalent to that cut. Reasons for this unsuccessful regeneration vary. Competition from shrubs or undesirable tree species may not allow growth of desired species. Physical site conditions after logging may reduce success rates of regeneration. Other contributing factors include inadequate natural seed supply, local climatic conditions, and browsing by animals.

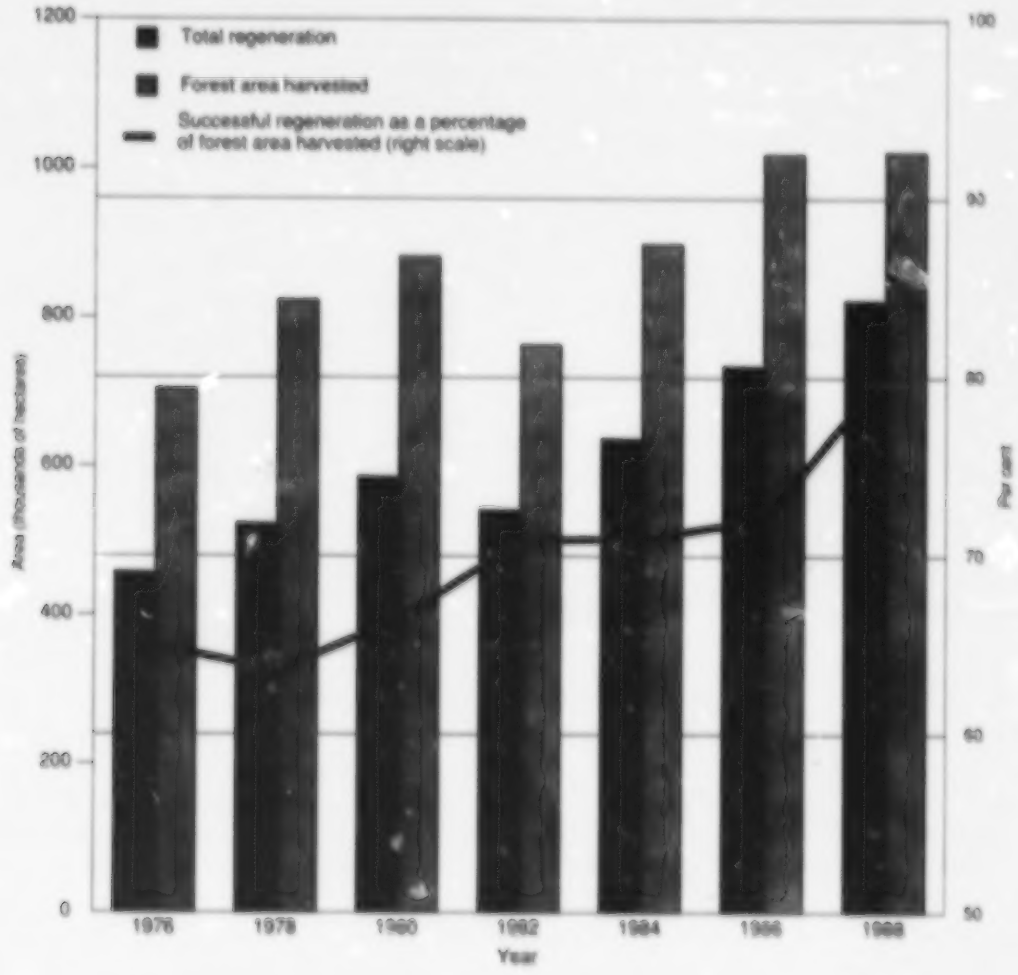
In 1976, in Canada, 156 000 hectares, or 22% of the total area harvested, were planted or seeded. By 1988, the total area planted or seeded had almost tripled to 451 000 hectares, or 44% of the total area harvested. The remaining cutover lands were left to regenerate naturally.

The indicator presented for forestry is:

* Regeneration success versus total forest area harvested

Indicator
Regeneration success versus total forest area harvested

Target Not defined



Canada's regeneration success and forest area harvested

Source: Kuhnke 1989, Forestry Canada, Economics and Statistics Directorate

This figure depicts, on a biennial basis from 1976 to 1988, total acreage cut versus total acreage of cut lands considered to have successfully regenerated. "Successfully regenerated areas" means that areas treated to establish a new forest meet minimum forest management agency criteria for the number of trees desired for a particular species or site. These criteria differ from province to province; efforts are being made to standardize criteria for reporting purposes. The line represents regeneration success as a percentage of area harvested. This percentage has increased from approximately 66% in 1976 to 81% in 1988.

Agriculture

Today, modern agriculture's demands on the land base to produce high-yielding crops and improved product quality require the application of chemical fertilizers, manures, and pesticides to maintain agricultural production. Agricultural activity has been intensifying as more and more available farmland is used for crop production.

One of the important factors influencing agricultural production is soil quality. As crops are harvested, changes occur in the nutrient balance of the soil. If certain nutrients are not replaced, nutrient depletion becomes inevitable. Chemical fertilizers are composed of essential plant nutrients, such as nitrogen, phosphorus, and potassium. These nutrients stimulate plant growth and substantially increase yields, even when natural nutrients have been depleted. However, excessive fertilizer use often has significant impacts on the environment. Nutrients not utilized by plants can be leached away and can have adverse effects on both groundwater and surface water systems. For example, high concentrations of phosphates can cause eutrophication in lakes and rivers, whereas high concentrations of nitrates can result in groundwater contamination.

Agricultural pesticides are widely used in Canada. They enhance agricultural productivity and product quality by reducing the impacts of weeds and pests on crop production. When pesticides are applied directly to crops or soil, only a portion is absorbed by the target weeds and pests. Residual pesticides can remain in the soil for a few days to several years, whereas mobile pesticides can be leached away. Some of these are very persistent and can contaminate groundwater, lakes, and streams and possibly affect fish, birds, and other wildlife. This has led to public concern about the potential impacts of these chemicals on the environment and human health. Work is ongoing to develop more selective, less persistent, and less mobile pesticides that will have less impact on non-target species and water quality.

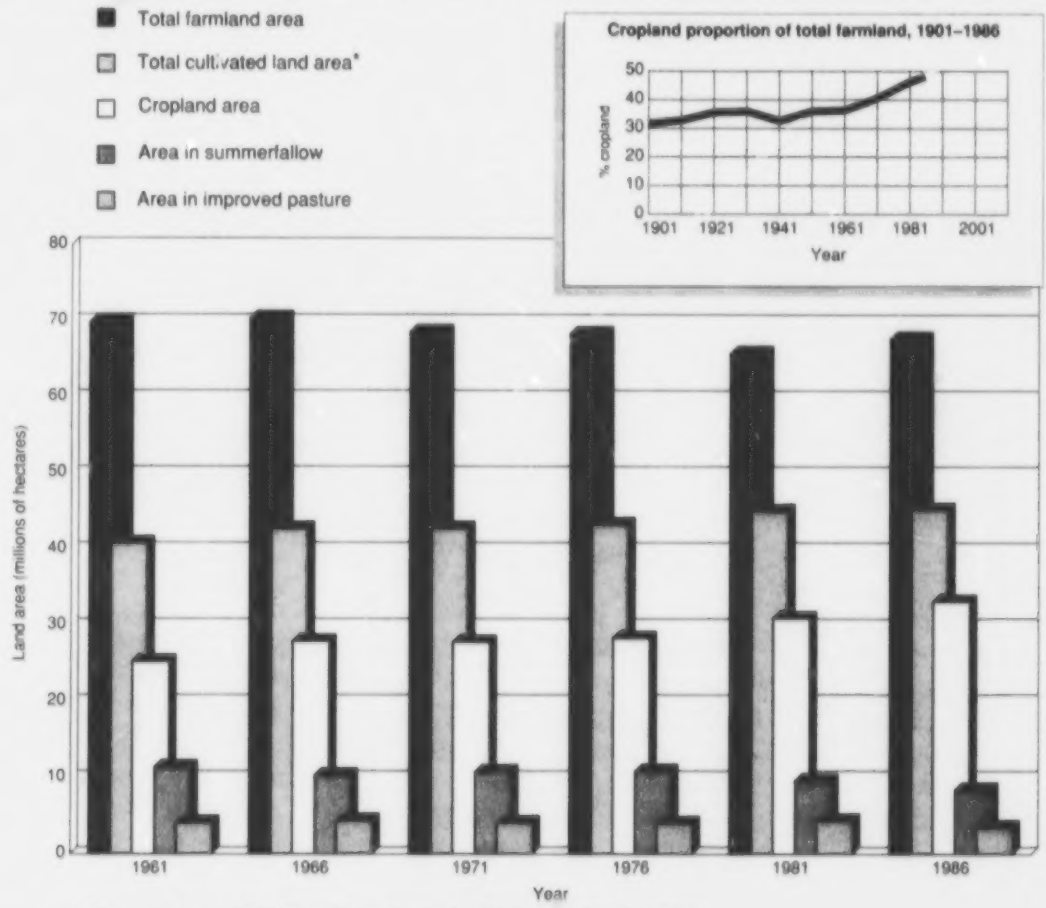
Concerns exist regarding the inclusion of the use of chemical fertilizers and agricultural pesticides as environmental indicators. The amount of chemical fertilizer used does not address the most significant factors associated with environmental risk, such as method and timing of application and the correlation between crop uptake and rates of application. At present, it is not possible to link fertilizer use data with crop yield data to assess properly the level and efficiency of fertilizer use. Similarly, the area of cultivated land treated with pesticides is a crude measure that does not adequately reflect the level of pesticide use. For example, judicious use of pesticides may reduce the total amounts of pesticides applied without reducing the area to be treated with pesticides. Furthermore, the area of land treated with pesticides does not give any indication of the persistence or selectiveness of pesticides used. Data on the total amount of pesticides used are not available on a national basis at the present time. Chemical fertilizer use and agricultural pesticide application on cultivated land are presented as preliminary agricultural indicators with the realization that these indicators require further development.

Preliminary indicators presented for agriculture are:

* Changes in agricultural land use
* Amount of chemical fertilizer used and its associated nutrient content
* Agricultural pesticide application on cultivated land

Indicator
Changes in agricultural land use

Target Not defined



Changes in agricultural land use in Canada, 1961–1986

* Cultivated land area includes land that is under crops, in improved pasture, or in summerfallow.

Source: Statistics Canada, Census of Agriculture

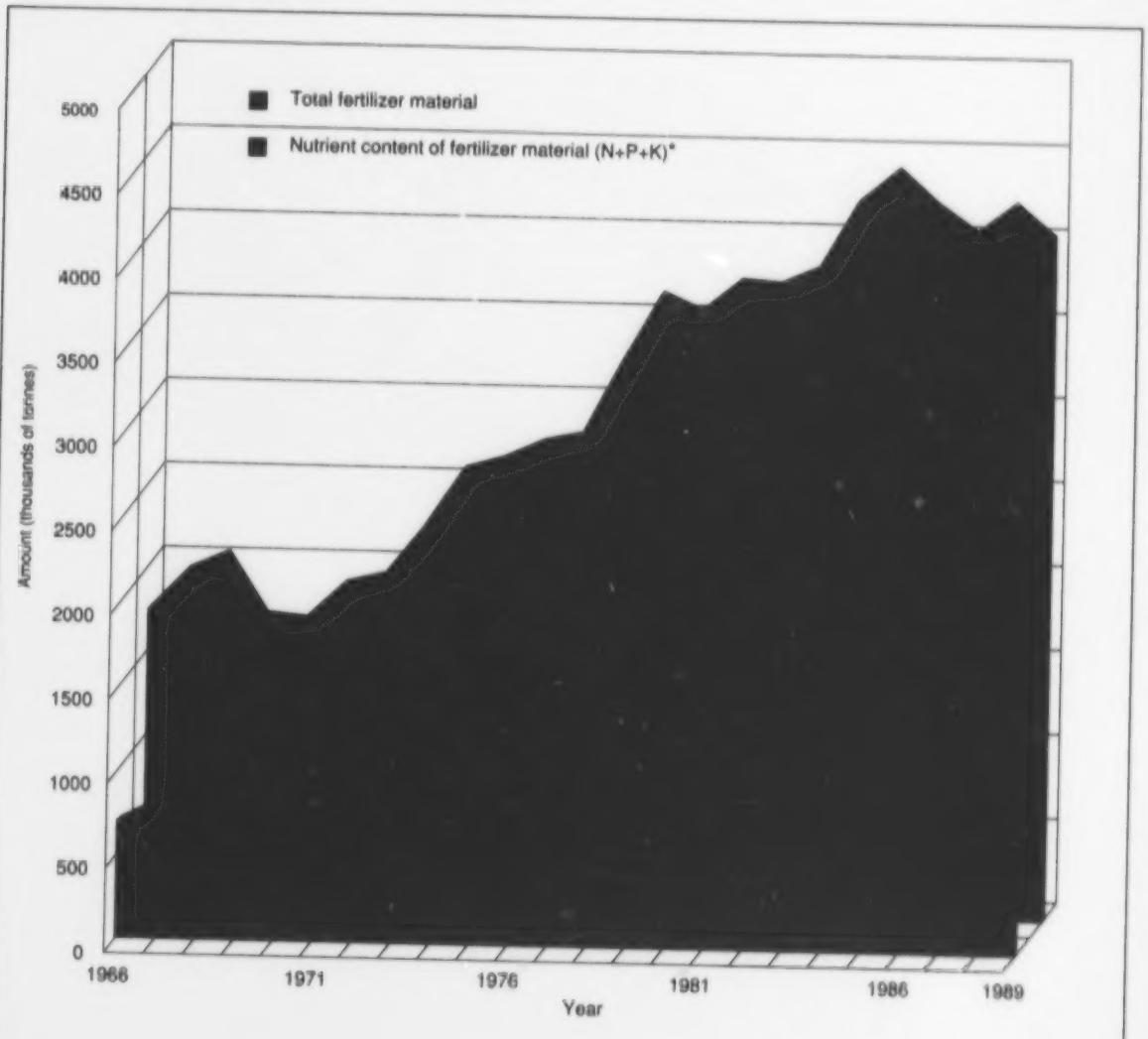
The amount of farmland in Canada remained relatively stable between 1961 and 1986, declining by only 3%. However, more land is being cultivated. Cultivated land, which includes land under crops, land in improved pasture (i.e., all pasture/grazing land to which such improvements as cultivation, irrigation, fertilization, and spraying have been made), or land in summerfallow (i.e., land normally in crops, left unseeded, possibly cultivated or sprayed during the year), increased by 11% in the same period. Within this category, the total area of land actively used for crops experienced significant increases. Cropland area rose from 25.3 million hectares in 1961 to 33.2 million hectares in 1986, an increase of 31%. The cropland proportion of farmland area rose from just over 30% of farmland in 1901 to almost 50% of farmland area in 1986. This increase in cropland area reflects an intensification of agricultural activity and an effort to increase agricultural production. Efforts to increase crop production are often associated with an increased use of chemical fertilizers or pesticides.

The area of cropland devoted to summerfallow decreased by 25% between 1961 and 1986. Summerfallowing conserves soil moisture and nutrients and has become a common practice in the Prairie provinces. However, the lack of crop cover increases susceptibility to soil erosion. The reduction in summerfallow area may indicate the adoption of improved soil conservation practices that reduce soil erosion and prevent degradation.

Indicator

Amount of chemical fertilizer used and its associated nutrient content

Target Not defined



Total chemical fertilizer used in Canada and its nutrient content, 1966–1989

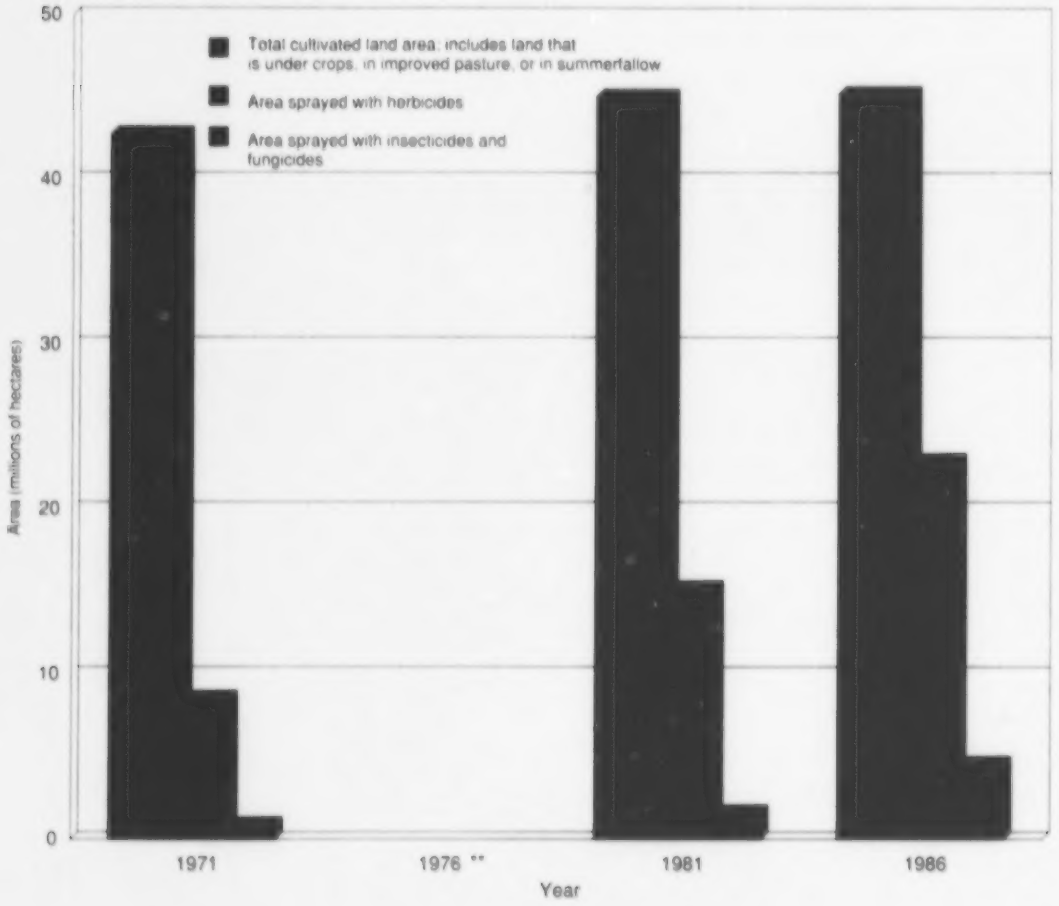
* (N+P+K) = nitrogen + phosphorus + potassium.

Source: Spearin and O'Connor 1990

Chemical fertilizer use on Canadian farms has increased steadily over the past two decades because of the combined effects of soil quality deterioration and increasing nutrient demands of higher-yielding crops. Between 1966 and 1989, the quantity of fertilizer applied to the soil increased by 133%, whereas the nutrient content of this fertilizer increased by 207%. The trend in increasing fertilizer use appears to have peaked in 1985 and levelled off somewhat in recent years.

Indicator
Agricultural pesticide application on cultivated land

Target Not defined



Agricultural pesticide* application on cultivated land in Canada, 1971–1986

* The area sprayed is counted only once for herbicide and once for insecticide, no matter how many applications are made.
** Data are not available for 1976.

Source: Statistics Canada, Census of Agriculture

There are three principal types of pesticides: herbicides, insecticides, and fungicides. Of these, herbicides are the most commonly used pesticides in Canadian agriculture and account for 71–77% of all pest control products sold in Canada over the last decade.

Despite increased concern over the environmental and health impacts associated with pesticides and efforts to curb agriculture's dependence on them (through such programs as integrated pesticide management), their use has continued to increase over the last two decades. Between 1971 and 1986, the area of cultivated land sprayed with herbicides increased by 168%. During this 15-year period, the cultivated land area treated with insecticides and fungicides increased by 403%.

Fisheries

In 1988, the international Food and Agriculture Organization (FAO) estimated that the world's marine and freshwater commercial catches were reaching the limit of the sustainability of the fisheries resource, evaluated at that time to be about 100 million tonnes per year. The FAO also projected that the demand for fish by the year 2000 could exceed 100 million tonnes per year if the demand for fish products continued to climb globally at the existing rate.

Over the years, serious concerns have been raised about the intensity of fishing on the Atlantic and Pacific coasts. Groundfish (bottom-dwelling) species such as cod and haddock have been under harvesting pressure for several decades because of their high market value. Populations of pelagic (open sea) species such as herring, on the other hand, have been undergoing significant fluctuations that are not necessarily due only to fishing pressures but could also be natural or the result of environmental factors such as climate change. Current knowledge and understanding of the mechanisms that contribute to biological capacity and population fluctuations of the different stocks are incomplete. In addition to the complexity of fish stock renewal, fish behaviour may vary from year to year because of changes in migration and distribution.

Information on commercial catches in Canadian waters off the Atlantic and Pacific coasts is essential for a complete picture of commercial fisheries in coastal areas of Canada. However, at the present time, information on the total commercial catches for the Pacific is not available.

In Canada, an active commercial fishing industry makes a significant economic contribution to coastal areas of the country as well as inland, mainly in the Great Lakes area. Since the early 1900s, the welfare of fish stocks in the Great Lakes has been affected by many man-made stresses, including changing harvest techniques and intensity; the introduction of sea lamprey, smelt, and zebra mussels; the loss of spawning areas because of dams and changes in shoreline land use; excessive loadings of nutrients from sewage, fertilizers, and soil erosion; and high loadings of toxic materials.

Toxic contaminants in fish have been responsible for closures of fisheries in western Lake Ontario and for intermittent closures of Walleye, bullhead, catfish, and eel fisheries in other areas. As well, Lake Trout, once a highly valued commercial fish, cannot be self-sustained and remains in the Great Lakes only because of expensive artificial restocking programs. In addition, quotas on commercial harvests were introduced in 1962 because of important stock fluctuations and were increased in all Great Lakes in 1984.

Changes to fish stocks cannot all be attributed to man-made causes, and it is difficult to accurately assess responsibility for these changes at this time. Nevertheless, barring evidence to the contrary, long-term trends in fish stock levels are regarded as an important indicator of overfishing and changes to the sustaining habitat in the Great Lakes Basin.

When interpreting the data, it should be noted that catch/harvest statistics, the most relevant available information, may not reflect the size or healtn of the fish stocks and can be used only as a measure of the fishing activity of the commercial stocks.

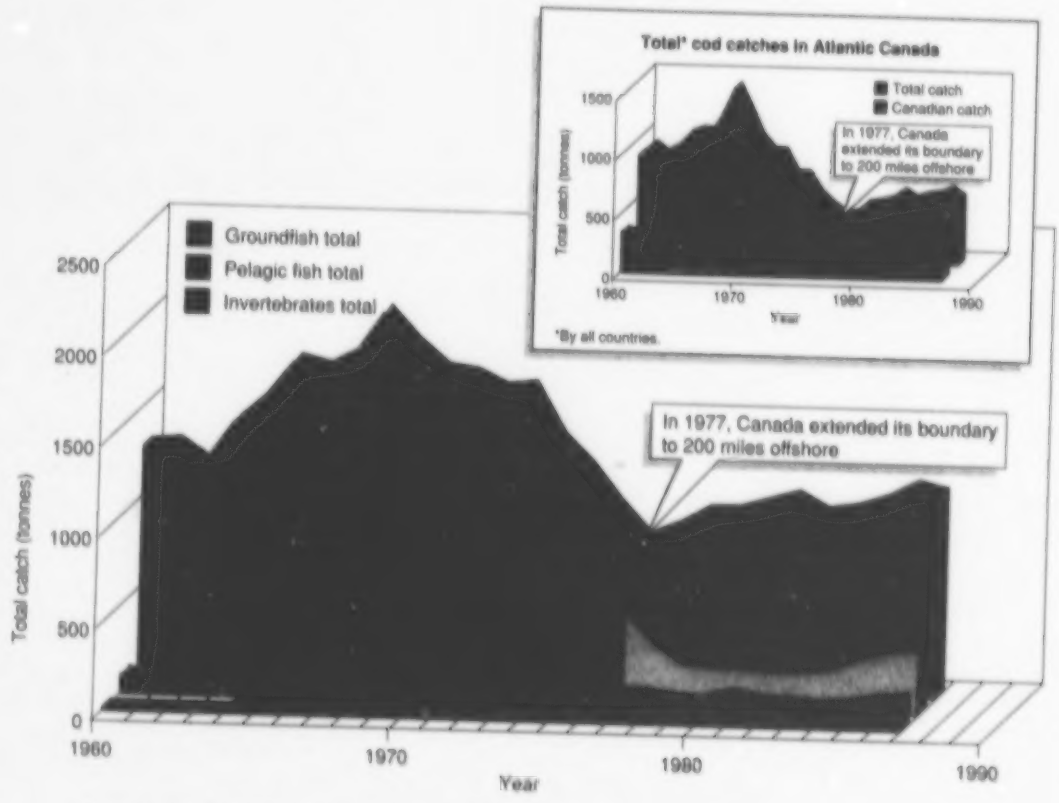
The indicators presented here for fisheries are:

* Total commercial fish catches in Canadian waters off the Atlantic coast
* Commercial fish harvest in the Great Lakes

Indicator

Total commercial fish catches in Canadian waters off the Atlantic coast

Target Not defined



Total* commercial fish catches in Atlantic Canada

* By all countries.

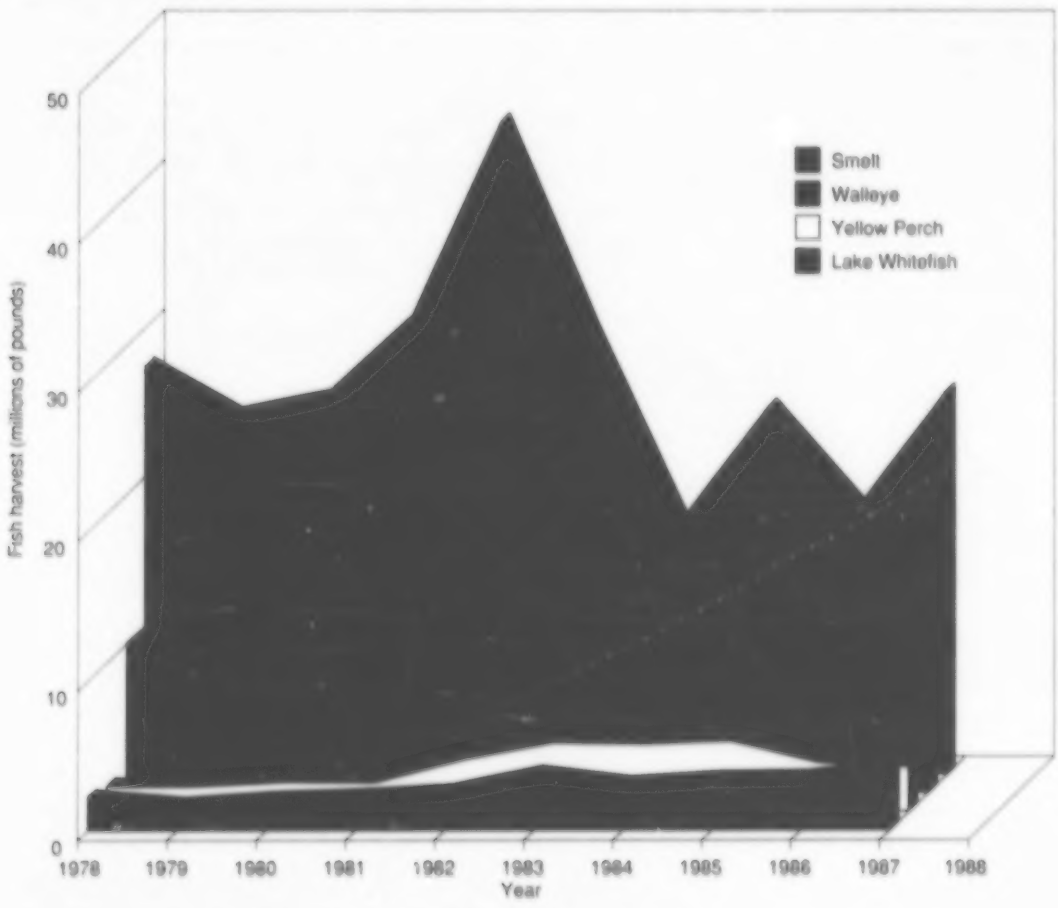
Source: Fisheries and Oceans Canada, Biological Sciences Directorate

The catch data used in this figure represent the commercial catches in Canadian waters off the Atlantic coast, which include Canadian catches as well as foreign catches for some species. It should be noted that catch trends are influenced by regulations and enforcements, changes in the natural abundance of the resource, market value, fishing techniques, and fishing efforts.

During the 1960s, the commercial catch in Canadian waters increased rapidly for groundfish and pelagic fish species, primarily because fishing was open to all countries beyond 12 miles offshore. In the early 1970s, stocks started to fall, mainly due to the intensity of the harvesting. In 1977, Canada extended its jurisdiction from 12 miles offshore to 200 miles offshore. Since then, the catch levels for Canadian fishermen have been set at an exploitation rate to allow for the conservation of the fish resources and the rebuilding of certain stocks. Some pelagic stocks were still recovering by 1987. In contrast, many groundfish stocks increased, except for some cod stocks, which declined in recent years. Natural fluctuation in the number of fish surviving to adulthood is thought to be one of the contributors to this decline. In 1990, Canada implemented the Atlantic Fisheries Adjustment Program with the goal of rebuilding certain fish stocks in the Northwest Atlantic.

Indicator
Commercial fish harvest in the Great Lakes

Long-term objective Under the Great Lakes Fisheries Commission goal, self-sustaining stocks of native fish species are restored (e.g., Lake Trout).



Commercial fish harvest, 1978–1987: Great Lakes total

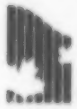
Source: Fisheries and Oceans Canada and Ontario Ministry of Natural Resources

Commercial fisheries in the Great Lakes have shown serious declines in some fish stocks due to a combination of factors, including competition between new and existing species, changes in habitat, contamination by toxic chemicals, and shoreline development.

Lake Trout, once a highly valued fish in Lake Huron and Lake Superior, was almost eliminated by the introduction of sea lamprey. Harvesting continues, but at less than 10% of traditional levels.

Walleye, an important commercial fish, especially in Lake Erie, saw its population depleted in the 1960s and was affected by mercury contamination in the 1970s. As a result of a 3-year fishing closure, Walleye stocks have recovered tremendously in some parts of their range.

Smelt, which was introduced in the early 1900s, accounts for the largest portion of the annual total catch in the Great Lakes. It also shows significant year-to-year variations in catches, indicating that stocks are depressed and increasingly dependent on a single year-class.



Water Use

Water is essential for human health and the health of the environment. But water is also a commodity, a renewable resource. The availability of a safe and sufficient water supply underpins our whole economy: it is required for irrigating crops, supporting the fishery, transporting goods, driving hydro generating turbines, facilitating the process and products of industry, and diluting societal wastes.

Until the 1970s, Canadian water management was supply oriented. However, the costs of dams and diversions have escalated, as has public opposition to the societal and environmental disruption such structures often impose. The more recent approach to water management is not to make more water available to satisfy continuing growth, but to support such growth through moderating demands upon the water resource to achieve greater efficiency in use.

One of the main obstacles to reducing demands upon the water resource is the widely held perception that not only do we have an abundant water supply but the resource is "a free good." Because water is undervalued, it tends to be squandered and overused for the dilution of wastes, as users have little incentive to conserve the resource or to treat their effluents.

At present, long-term data are not available for reporting trends in the relationship between water pricing and water use. Monitoring has been initiated and will provide useful data for future indicators.

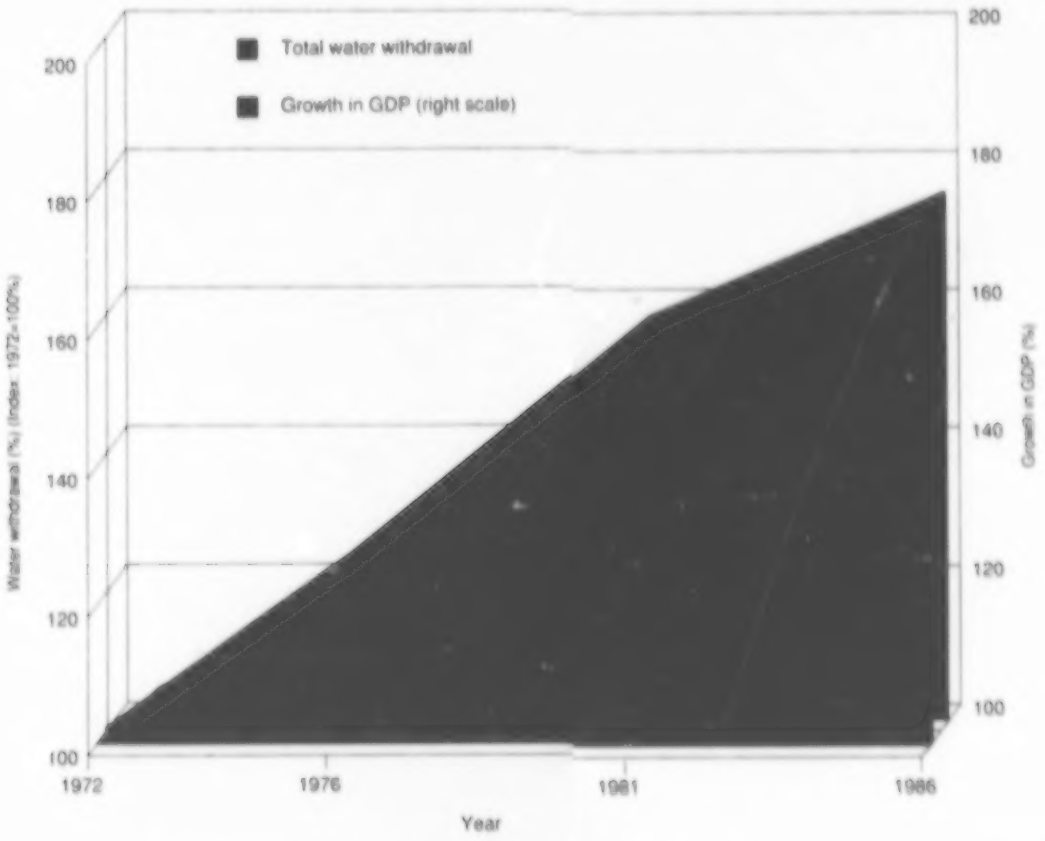
Water use surveys are conducted by Environment Canada every 5 years for industrial uses (including agriculture) and every 3 years for municipal uses. Taken together, these uses account for most of the water withdrawal in Canada. The indicators selected to provide trend information on water withdrawals and use are:

* Total water withdrawal compared with growth in Gross Domestic Product (GDP)
* Rates of water withdrawal and consumption by key economic sectors
* Rates of water recirculation by key industrial sectors
* Daily household water use per capita

Indicator

Total water withdrawal compared with growth in Gross Domestic Product (GDP)

Target Not defined



National trends in water withdrawal and economic growth

Source: Environment Canada, MUD and INUDAT databases; Statistics Canada

The water intake index is based on total water withdrawal for five key sectors, expressed as a percentage of annual reliable stream flow and indexed to the base year 1972. The five key sectors are agriculture, municipal, mining, manufacturing, and thermal power.

Over the 15-year period of 1972–1986, trends in water use were similar to trends in growth in GDP. Water withdrawal increased by approximately 75% between 1972 and 1986. In 1986, this withdrawal constituted about 2% of the reliable water supply (supply that can be counted upon 19 years out of 20).

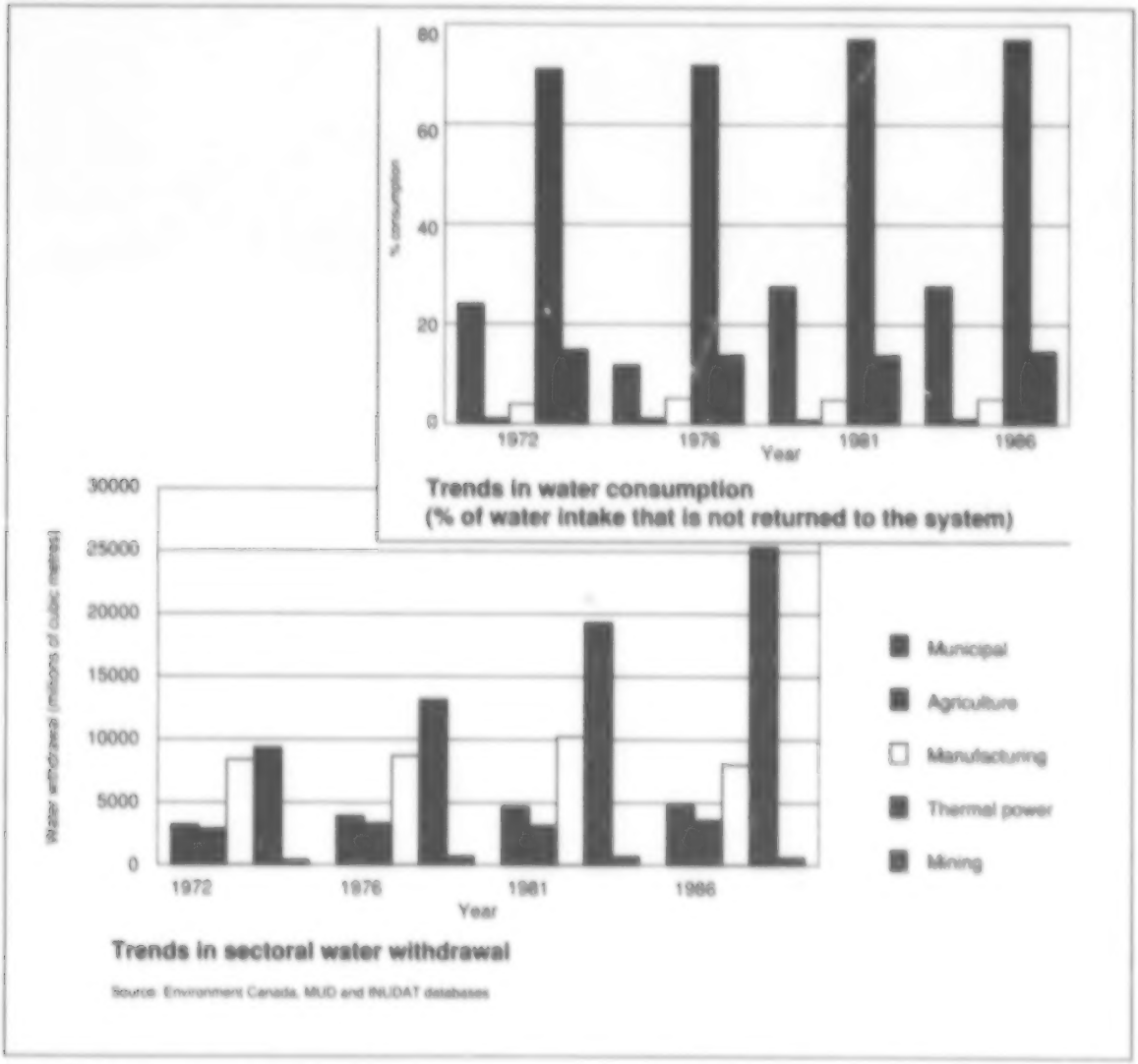
Around 90% of the withdrawn water is returned to source; however, these discharges may contaminate the receiving waters and reduce their suitability for other uses unless they are treated first.

The favourable national picture of water supply and withdrawal disguises regional variations, such as in the southern Prairies, where withdrawal requirements may exceed 50% of the available supply. Most experts agree that 50% of the available supply should be reserved for supporting aquatic life and other non-withdrawal uses.

Indicator

Rates of water withdrawal and consumption by key economic sectors

Target Not defined



The total water withdrawal for all five sectors increased from approximately 24 billion cubic metres in 1972 to just over 42.2 billion cubic metres in 1986, with the thermal power sector accounting for a significant portion of the increase.

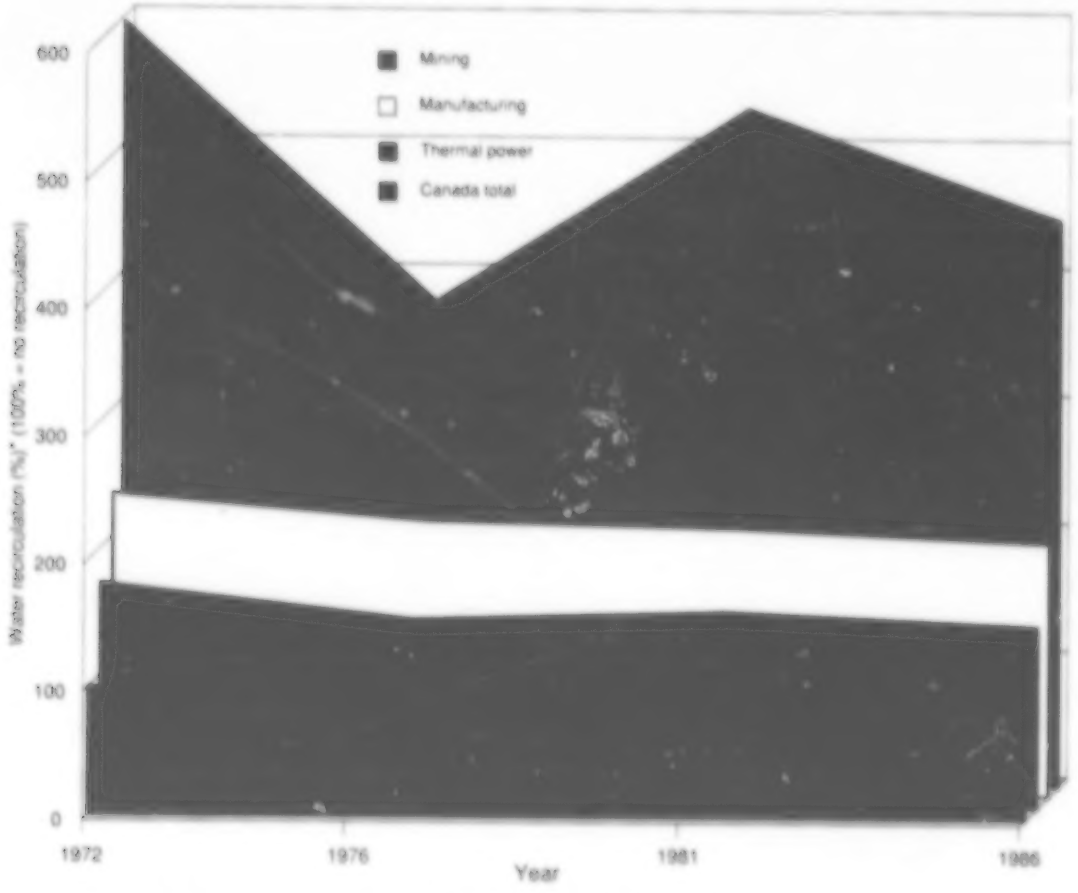
Increased water withdrawal by the thermal power sector is due to the rapid growth in demand for electricity and the greater proportion of energy demand being met by nuclear power plants, which use more cooling water than conventional thermal plants.

The manufacturing sector is an exception to the general trend and shows a 5% reduction in withdrawal in 1986. A survey planned for 1991 may indicate if this reduction is a genuine shift in withdrawal trends for the manufacturing sector or a function of economic trends.

Agriculture was consistently the highest consumer (approximately 77%) of intake water; water consumed is not returned to source. In the Prairie region, where supplies are already limited, such a high consumption rate may have negative implications for instream requirements, such as fish and wildlife maintenance. Thermal power is the lowest consumer, averaging a consumption rate of 1% over the 15-year period of 1972–1986.

Indicator
Rates of water recirculation by key industrial sectors

Target Not defined



Trends in water recirculation by select industrial sectors

*Water Recirculation Index: The higher the index percentage, the greater the amount of intake water recirculated; 100% = no recirculation.

Source: Environment Canada, MUD and INUDAT databases

The recirculation rate reflects the ratio, expressed as a percentage, between total water use and intake requirements. Consequently, there is no recirculation taking place when the ratio between total use and intake equals 1 (i.e., 100% = no recirculation).

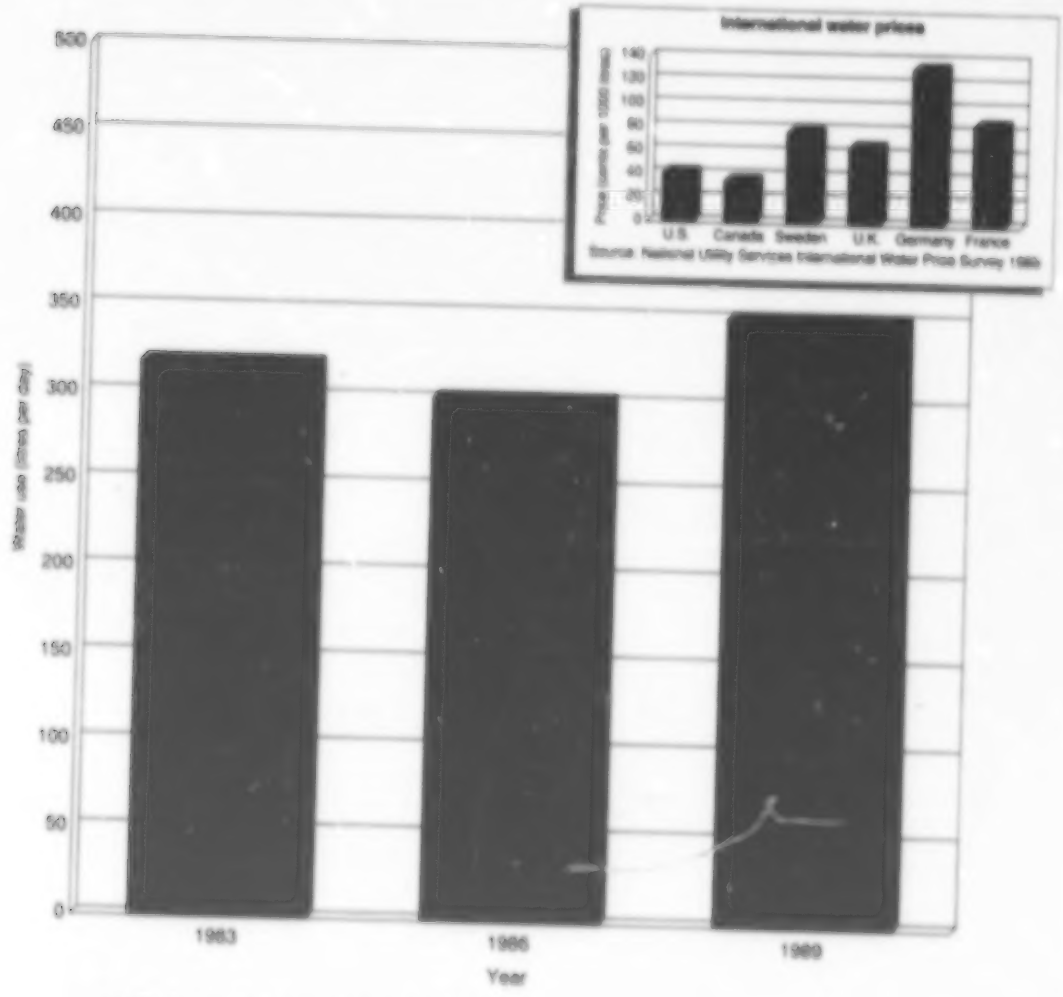
The overall trend in recirculation for the three industrial sectors declined by 30% between 1972 and 1986. This trend suggests that, although recirculation practices are encouraged in some industries, especially in water-short regions, there has been little economic incentive to increase the level of recirculation.

The mining sector leads the other sectors in recirculation, even though its rate declined by about 150% between 1972 and 1986. The sharp decline in 1976 is due in part to a change in survey methodology.

Although nationwide the manufacturing sector showed a 35% decrease between 1972 and 1986, a regional breakdown would indicate that recirculation levels increased among industries in the water-short areas of the country (e.g., the Prairies). Thermal power is the only sector that showed an overall increase in recirculation rates, largely due to a change in cooling technology. The agricultural and municipal sectors do not recirculate a significant amount of water and are not included in this graph.

Indicator
Daily household water use per capita

Target Not defined



Daily household water use per capita

Source: Environment Canada, MUD database

Overall, water withdrawal per capita for household use increased by approximately 8% from 1983 to 1989. There are insufficient data at this time to indicate whether or not this is part of a continuing trend.

According to a 1990 draft report by the Organisation for Economic Co-operation and Development comparing municipal water use in select countries, Canadian water use was double the European rate. This is likely a function of both price and public perception regarding abundance of the resource. More efficient household use would reduce the demands placed upon municipal water supply and treatment systems.

An international comparison of water prices charged by select industrial countries is presented in the insct graph. These prices do not include the cost of sewage treatment. If this cost were to be included in Canada, the cost per 1000 litres would rise to 47 cents. This cost is still well below European prices. By comparison, bottled water on the average costs 500 dollars for 1000 litres.

Energy

Abundant energy resources have been a cornerstone of the development of the Canadian economy. Between 1983 and 1987, the energy sector represented an average of 8% of Canada's Gross Domestic Product (GDP), 19% of gross investment, 12% of gross export income, and 4% of employment. Energy expenditures are also a major component of the budgets of industry, governments, and individuals.

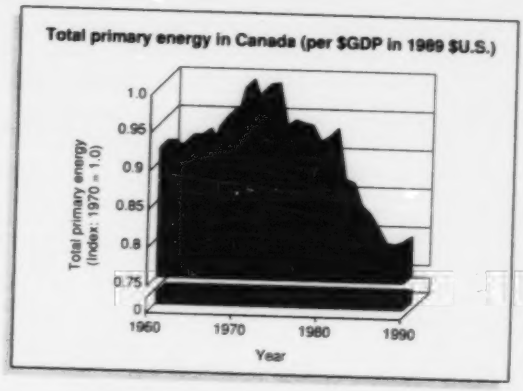
Our level of energy consumption and our choice of energy supply options can have profound effects on the environment. Climate change, acid rain, and the deteriorating quality of urban air and water are just some of the environmental concerns associated with energy production and use. The environmental stresses associated with the extraction, transformation, and consumption of energy can be expected to increase if current supply and consumption patterns are maintained.

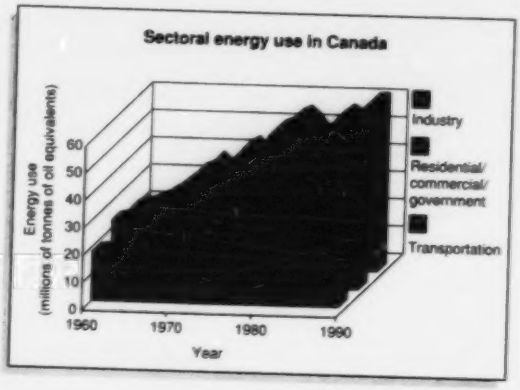
The significant impacts that the energy sector has on the environment and the economy suggest that energy resources should be used wisely. The following indicators are presented for monitoring the energy/environment relationship in Canada:

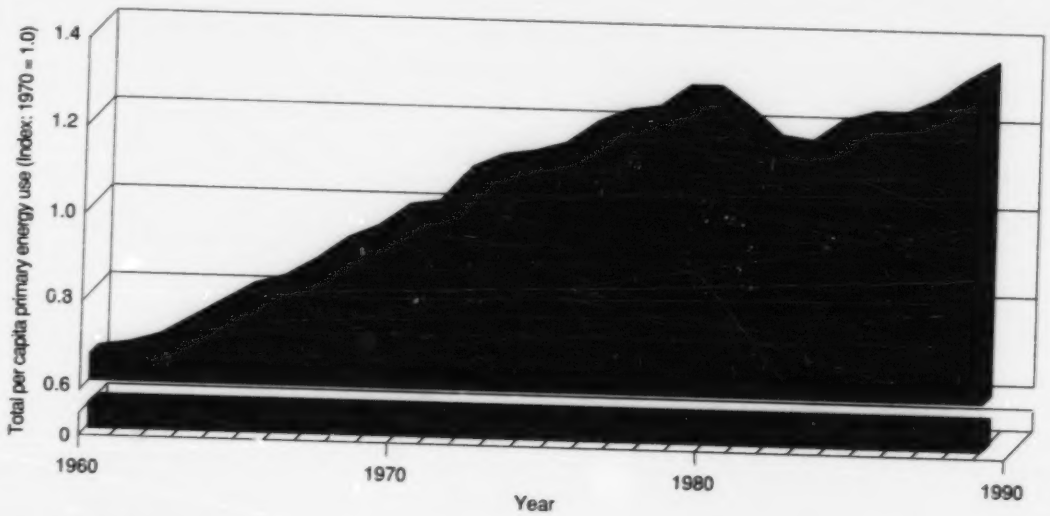
* Total per capita primary energy use
* Emissions of carbon dioxide (CO_2) per unit of energy consumed
* Fossil fuel intensity of primary energy demand

Indicator
Total per capita primary energy use

Target Not defined







Total per capita primary energy use in Canada

Source: Energy, Mines and Resources Canada

Energy demand does not, in itself, measure environmental stress, and it is therefore used here as a proxy for the level of impact that energy use can have on the environment. The graph shows that per capita use of primary energy (total energy available from natural resources) in Canada has returned to its long-term upward trend after a brief fall in the 1980s. The decline in the 1980s had a number of causes, including high oil prices, economic recession, and a large-scale conservation effort.

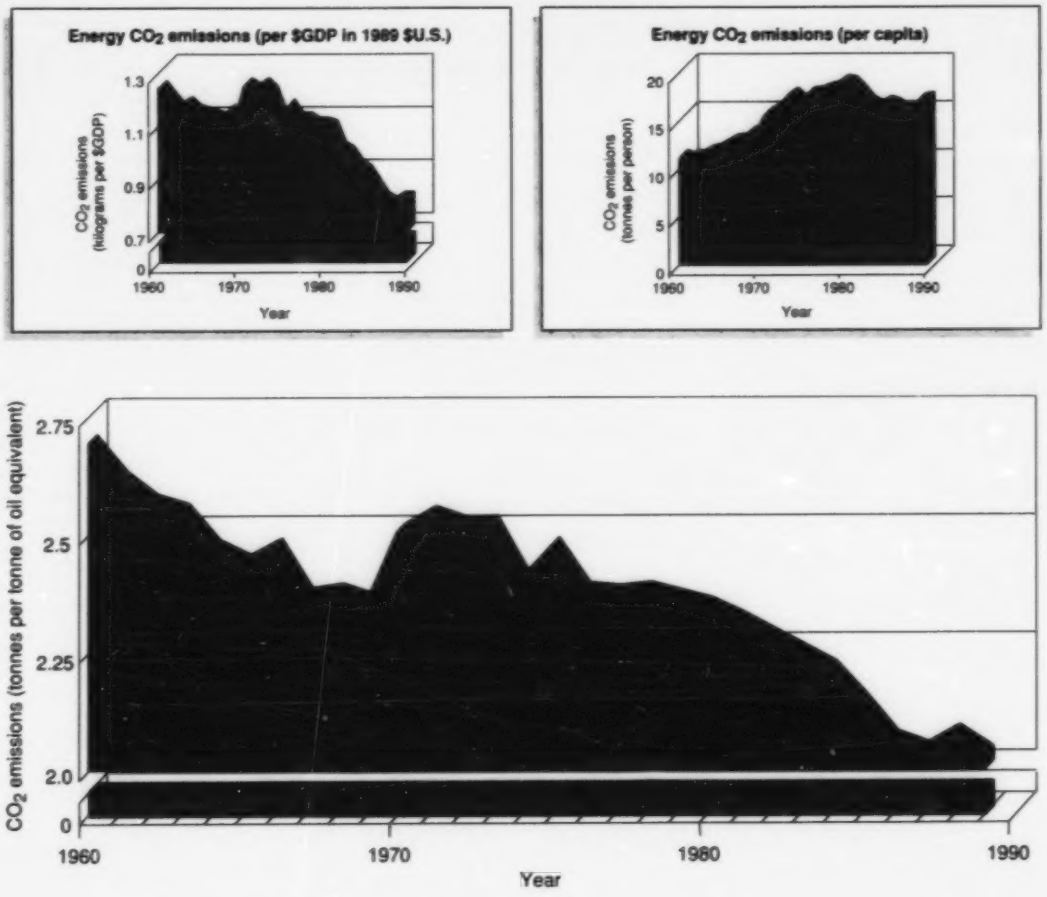
The inset depicts trends in energy consumption in Canada, broken down by sector and in relation to Gross Domestic Product (GDP). All sectors showed a definite decline in energy use in the early 1980s, for reasons similar to those cited above. Energy use in the residential/commercial sector has flattened out recently, but it has continued to increase steadily in the industrial sector.

Relative to economic activity, energy use has declined significantly over the past 20 years. This trend has reversed, recently, as a result of relatively strong economic growth and constant or declining real energy prices.

Indicator

Emissions of carbon dioxide (CO_2) per unit of energy consumed

Target Not defined



CO_2 emissions per unit of energy consumed

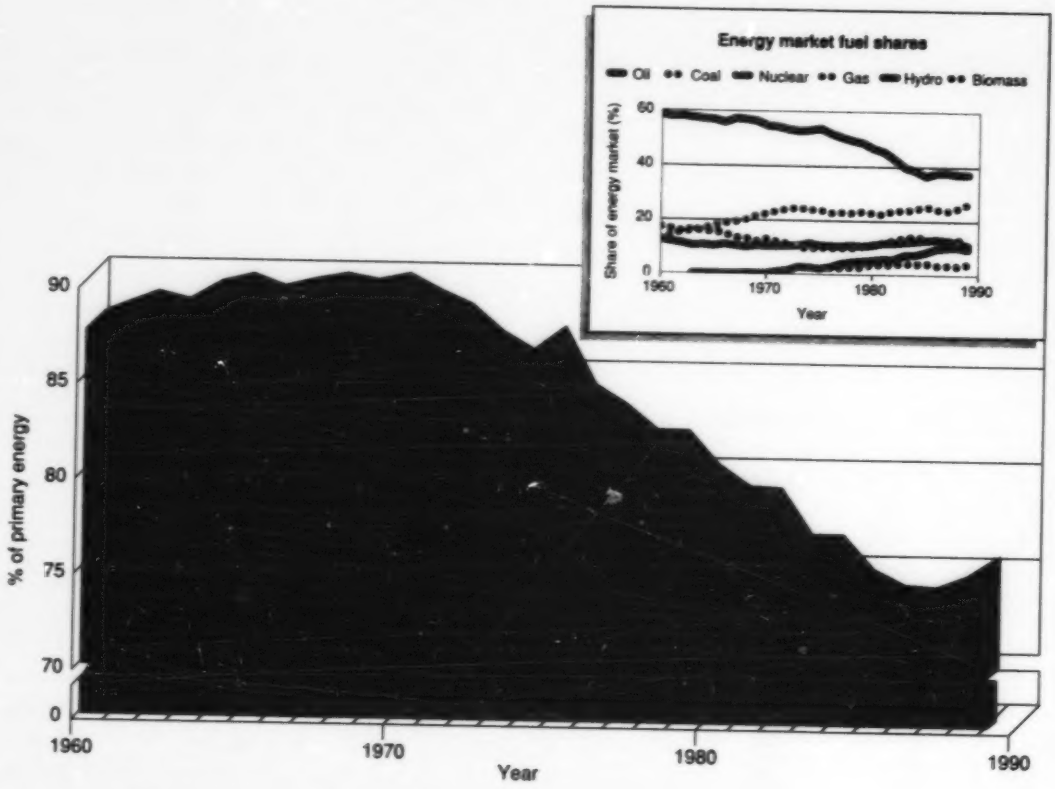
Source: Energy, Mines and Resources Canada

Carbon dioxide (CO_2) emissions in Canada have risen significantly during this century. One way of depicting CO_2 emissions is to relate them to the total amount of primary energy consumed. The intensity of CO_2 emissions in relation to primary energy (in tonnes of oil equivalent) is shown in the graph. Note that the downward trend has a limit, unless there is a continuing increase in the share of hydro and nuclear energy. Thus, although there is some room for improvement in CO_2/energy intensity in Canada, it is modest. Further reductions in total CO_2 emissions can be achieved, however, through energy efficiency, conservation, and the development of renewable energy sources.

With the exception of the last decade, Canada's per capita generation of CO_2 has increased steadily. On the other hand, the long-term trend of CO_2 emissions in relation to economic growth has been downwards, as efficiency of energy use increased and fuel switching to natural gas, hydro, and nuclear took place. An increased use of petroleum products is partly responsible for the recent rise in CO_2 emissions. Efficiency improvements in the future offer considerable opportunities for further declines in the ratio of CO_2 emissions to Gross Domestic Product.

Indicator
Fossil fuel intensity of primary energy demand

Target Not defined



Fossil fuels and primary energy (% of primary)

Source: Energy, Mines and Resources Canada

The energy sources that comprise Canada's primary energy requirements have different impacts on the environment. Fossil fuels are of particular concern because of their large contribution to "greenhouse gas" emissions and therefore global climate changes. The more carbonaceous the fuel, the more carbon dioxide (CO_2) is produced when it is burned. Consequently, coal produces more CO_2 than oil, and oil more than natural gas. Burning wood releases CO_2 also, although there would be no net effect as long as the forest is regenerated. Hydro power's environmental impacts relate principally to the effects associated with the flooding of new reservoirs, whereas concerns with nuclear power relate principally to long-lived radioactive wastes.

The fossil fuel share of primary energy in Canada dropped dramatically between 1970 and 1985. The relative decrease in fossil fuel consumption is attributed to a number of causes, including increases in domestic oil prices and the strong growth of hydro and nuclear energy. The increase in the fossil fuel share of primary energy in the last 2 years has been concurrent with lower oil prices.

The inset shows the share of the energy market held by the various energy sources available in Canada. Oil shares dropped steadily to 1985 with increasing oil prices but then remained essentially flat after the oil price decline of early 1986. The shares held by gas and nuclear energy have increased over time. Data on biomass (any kind of organic substance that can be turned into fuel) prior to 1976 were not included in the International Energy Agency database used for the graph. The renewable energy resource share of Canada's primary energy demand, including biomass, is estimated to be approximately 5%.

Selected References

ATMOSPHERE

Climate Change

Books/Reports

Hammond, A.L., E. Rodenburg, and W. Moomaw. 1990. Accountability in the greenhouse. Nature (London) 347: 705–706.

Hilborn, J., and M. Still. 1990. Canadian Perspectives on Air Pollution. SOE Report 90-1. Environment Canada, State of the Environment Reporting. Ottawa.

Jones, P.D., T.M.L. Wigley, P.W. Wright, and T.A. Boden. 1990. Global and Hemispheric Annual Temperature Variations Between 1861 and 1988. Publication No. 3421. Oak Ridge National Laboratory, Environmental Sciences Division. Oak Ridge, Tennessee.

Scripps Institute of Oceanography. Cited in: World Resources Institute. 1990. World Resources 1990–91. Oxford University Press. New York.

World Resources Institute. 1990. World Resources 1990–91. Oxford University Press. New York.

Data on File

Energy, Mines and Resources Canada, Economic and Fiscal Analysis Branch. re: Canadian energy-related emissions of carbon dioxide.

Environment Canada, Atmospheric Environment Service. re: Carbon dioxide database.

Stratospheric Ozone Depletion

Books/Reports

World Resources Institute. 1990. World Resources 1990–91. Oxford University Press. New York.

Data on File

Environment Canada, Atmospheric Environment Service. re: World ozone database.

Environment Canada, Environmental Protection, Commercial Chemicals Branch. re: Canadian consumption of ozone-depleting chemicals.

Radiation Exposure

Books/Reports

Health and Welfare Canada. 1989. (Draft.) Environmental Radioactivity in Canada, 1988. Radiological Monitoring Annual Report. Environmental Health Directorate, Health Protection Branch. Ottawa.

Personal Communication

Marshall, H. 1990. Health and Welfare Canada, Health Protection Branch, Bureau of Radiation and Medical Devices, Environmental Radiation Hazards Division. Ottawa. re: Radioactivity in surface air and milk.

Data on File

Health and Welfare Canada, Health Protection Branch, Bureau of Radiation and Medical Devices, Environmental Radiation Hazards Division. re: Radioactivity in surface air and milk.

Acid Rain

Books/Reports

Pinault, P. 1990. (Draft.) LRTAP 1990 Assessment Report, Part 2: Emissions and Controls. Environment Canada, Industrial Programs Branch. Ottawa.

Data on File

Environment Canada, Environmental Protection, Regulatory Affairs and Program Integration Branch, Inventory Management Division. re: SO_2 and NO_x emissions in Canada.

Outdoor Urban Air Quality

Books/Reports

Environment Canada. 1989. National Air Pollution Surveillance: Annual Summary 1987. Report EPS 7/AP/20. Environmental Protection. Ottawa.

Environment Canada. 1990. Canadian Emissions Inventory of Common Air Contaminants (1985). Report EPS 5/AP/3. Environmental Protection. Ottawa.

Environment Canada. 1990. National Urban Air Quality Trends 1978 to 1987. Report EPS 7/UP/3. Environmental Protection. Ottawa.

Hilborn, J., and M. Still. 1990. Canadian Perspectives on Air Pollution. SOE Report No. 90-1. Environment Canada, State of the Environment Reporting. Ottawa.

Organisation for Economic Co-operation and Development. 1990. OECD Environmental Data Compendium 1989. Paris.

Statistics Canada. 1990. Canadian Economic Observer; Historical Statistical Supplement 1989/90. Catalogue No. 11-210. Ottawa.

Statistics Canada. Road Motor Vehicle Registrations. Catalogue No. 53-219, Annual. Ottawa.

Personal Communication

Dann, T. 1990. Environment Canada, Environmental Protection, Pollution Measurement Division. Ottawa. re: Ozone map data.

Furmanczyk, T. 1990. Environment Canada, Environmental Protection, Regulatory Affairs and Program Integration Branch. Ottawa. re: Common air pollutants data.

Data on File

Environment Canada, Environmental Protection, Regulatory Affairs and Program Integration Branch, Inventory Management Division. re: National emission and air quality data for common and toxic air pollutants.

WATER

Freshwater Quality

Books/Reports

Bird, P.M., and D.J. Rapport. 1986. State of the Environment Report for Canada. Environment Canada. Ottawa.

Fisheries and Environment Canada. 1977. Surface Water Quality in Canada: An Overview. Ottawa.

Frank, R., and L. Logan. 1988. Pesticide and industrial chemical residues at the mouth of the Grand, Saugeen and Thames rivers, in Ontario, Canada, 1981–85. Archives of Environmental Contamination and Toxicology 17: 741–754.

Great Lakes Advisory Board. 1986. Literature Review of the Effects of Persistent Toxic Substances on Great Lakes Biota: Report of the Health of Aquatic Communities Task Force. Windsor.

Great Lakes Water Quality Board. 1987. Inventory of Major Municipal and Industrial Point Sources Discharges. Report to the International Joint Commission (IJC). Windsor.

House, M. 1987. Water Quality Indices as Indicators of Ecosystem Change. Workshop. May 27–29, 1987. Institute for Environmental Studies, University of Toronto. Toronto.

Inhaber, H. 1975. An approach to a water quality index for Canada. The Journal of the International Association for Water Pollution Research 9(9): 821–823.

Losier, L. 1990. Environmental Status Report for the Canadian Petroleum Refining Industry. Report EPS 1/PN/3. Environment Canada, Environmental Protection. Ottawa.

Muldoon, P. 1989. Toxic Water Pollution in Canada: Regulatory Principles for Reduction and Elimination. Canadian Institute of Resources Law.

National Research Council of the United States and the Royal Society of Canada. 1985. The Great Lakes Water Quality Agreement: An Evolving Instrument for Ecosystem Management. National Academy Press. Washington, D.C.

Office of the Commissioner for the Environment. 1988. Victoria's Inland Waters, State of the Environment Report. Melbourne, Australia.

Pearse, P., F. Bertrand, and J. MacLaren. 1985. Currents of Change: Final Report, Inquiry on Federal Water Policy. Ottawa.

Statistics Canada. 1986. Human Activity and the Environment: A Statistical Compendium. Analytical Studies Branch, Structural Analysis Division. Ottawa.

Task Force on Water Quality Guidelines, Canadian Council of Resource and Environment Ministers. 1987. Canadian Water Quality Guidelines. Ottawa.

Data on File

Environment Canada, Environmental Protection, Industrial Programs Branch. re: National inventory of municipal waterworks and wastewater systems database (MUNDAT).

Environment Canada, Environmental Protection, Industrial Programs Branch. re: BOD and TSS discharges from pulp and paper mills.

Environment Canada, Environmental Protection, Waste Management Branch. re: Waste removal coefficients.

Environment Canada, Inland Waters Directorate, Water Planning and Management Branch. re: Municipal water use database (MUD).

Environment Canada, Inland Waters Directorate, Water Planning and Management Branch. re: Industrial water use database (INUDAT).

Environment Canada, Inland Waters Directorate, Water Quality Branch. re: National water quality database (NAQUADAT).

Toxic Contaminants in the Freshwater Ecosystem

Books/Reports

Bishop, C., and D.V. Weseloh. 1990. Contaminants in Herring Gull Eggs from the Great Lakes. SOE Fact Sheet 90-2. Environment Canada, State of the Environment Reporting. Ottawa.

Colborn, T.E., A. Davidson, S. Green, R.A. Hodge, C.I. Jackson, and R. Liroff. 1990. Great Lakes, Great Legacy? The Conservation Foundation, Washington, D.C., and The Institute for Research on Public Policy, Ottawa.

Day, K., and E.D. Ongley. 1988. Biology in the new regulatory framework for aquatic protection. In: Proceedings of the Alliston Workshop. Environment Canada. Burlington, Ontario.

Department of the Environment. Environmental Contaminant Monitoring Subcommittee. 1981. The Selection of National Biological Monitoring Species. Workgroup Report. Ottawa.

Environment Canada. 1990. (Draft.) The Great Lakes Basin: A focus on the aquatic ecosystem. In: Government of Canada. 1991 State of the Environment Report for Canada. Ottawa.

Fox, G., and D.V. Weseloh. 1987. Colonial waterbirds as bio-indicators of environmental contamination in the Great Lakes. In: Diamond, A.W., and F. Filion (eds.). Value of Birds. ICBP Technical Report No. 6. International Council on Bird Preservation. Cambridge, England.

Great Lakes Water Quality Agreement. 1990. Ecosystem Objectives for Lake Ontario. International Joint Commission. Windsor.

International Joint Commission. 1985. PCB's: A Case Study. Proceedings of a Workshop on Great Lakes Research Co-ordination. Windsor.

International Joint Commission. 1987. Report on the Aquatic Ecosystem Objectives. Toledo, Ohio.

International Joint Commission. 1988. Rehabilitation of Lake Ontario: The Role of Nutrient Reduction and Food Web Dynamics. Windsor.

International Joint Commission. 1990. Fifth Biennial Report on Great Lakes Quality, Part II. Windsor.

International Joint Commission and the Great Lakes Fishery Commission. 1985. A Conceptual Approach for the Application of Biological Indicators of Ecosystem Quality in the Great Lakes Basin. Windsor.

Mineau, P., G.A. Fox, R.J. Norstrom, D.V. Weseloh, D.J. Hallett, and J.A. Ellenton. 1984. Using the Herring Gull to monitor levels and effects of organochlorine contamination in the Great Lakes. In: Nriagu, J.O., and M.S. Simmons. Toxic Contaminants in the Great Lakes. Wiley Inc. Toronto.

Weseloh, D.V., T.W. Custer, and B.M. Braune. 1989. Organochlorine contaminants in eggs of Common Terns from the Canadian Great Lakes in 1981. Environmental Pollution 59: 141–160.

Weseloh, D.V., P. Mineau, and J. Struger. 1989. Geographical distribution of contaminants and productivity measures of Herring Gulls in the Great Lakes: Lake Erie and connecting channels 1978/79. The Science of the Total Environment 91: 141–159.

Data on File

Environment Canada, Canadian Wildlife Service, Ontario Region, Canada Centre for Inland Waters. re: Herring Gull Eggs Monitoring Program.

Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Bayfield Institute. re: Contaminants Surveillance Program.

Marine Environmental Quality

Books/Reports

Menon, A.S. 1988. Molluscan shellfish and water quality problems in Atlantic Canada. Toxicity Assessment: An International Journal 3: 679–686.

Personal Communication

Cloutier, G. 1990. Environment Canada, Inland Waters Directorate, Environmental Emergencies Branch. Ottawa. re: Significant marine spills.

Elliot, J., and D. Noble. 1990. Environment Canada, Canadian Wildlife Service, Wildlife, Toxicology and Surveys Branch. Ottawa. re: Contaminant levels in seabird eggs.

Kay, B. 1990. Environment Canada, Environmental Protection, Pollution Abatement and Compliance Branch, Pacific and Yukon Region. Vancouver. re: Area closed to shellfish harvesting.

Menon, A. 1990. Environment Canada, Environmental Protection, Environmental Control Branch, Atlantic Region. Dartmouth. re: Area closed to shellfish harvesting.

Ruthman, T.E., and D. Halliburton. 1990. Environment Canada, Environmental Protection, Industrial Programs Branch. Ottawa. re: BOD and TSS discharged daily from coastal pulp mills.

Tate, D., and D. Lacelle. 1990. Environment Canada, Inland Waters Directorate, Water Planning and Management Branch. Ottawa. re: Municipal wastewater discharges.

Data on File

Environment Canada, Canadian Wildlife Service, Wildlife Toxicology and Surveys Branch. re: Contaminant levels in seabird eggs.

Environment Canada, Environmental Protection, Environmental Control Branch. re: Area closed to shellfish harvesting, Atlantic Region.

Environment Canada, Environmental Protection, Pollution Abatement and Compliance Branch. re: Area closed to shellfish harvesting, Pacific and Yukon Region.

Environment Canada, Environmental Protection, Industrial Programs Branch. re: Discharges from coastal pulp and paper mills.

Environment Canada, Environmental Protection, Waste Management Branch. re: National inventory of municipal waterworks and wastewater systems database (MUNDAT).

Environment Canada, Inland Waters Directorate, Environmental Emergencies Branch. re: National analysis of trends in emergencies database (NATES).

Environment Canada, Inland Waters Directorate, Water Planning and Management Branch. re: Municipal water use database (MUD).

BIOTA (LIVING ORGANISMS)

Biological Diversity at Risk

Books/Reports

Canadian Wildlife Service. 1988. Canadian Whooping Crane Recovery Plan. Environment Canada. Ottawa.

Canadian Wildlife Service. 1989. Endangered Species in Canada. Fact Sheet. Environment Canada.

Canadian Wildlife Service. 1990. (Draft.) A Wildlife Policy for Canada. Environment Canada. Ottawa.

Canadian Wildlife Service. 1990. (Draft.) Showing Biological Diversity in Canada. Environment Canada. Ottawa.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 1990. List of Designated Species. Ottawa.

Environment Canada, Canadian Wildlife Service. 1990. (Draft.) Wildlife and habitat. In: Government of Canada. 1991 State of the Environment Report for Canada. Ottawa.

Reid, W.V., and R.K. Miller. 1989. Keeping Options Alive: The Scientific Basis for Conserving Biodiversity. World Resources Institute. Washington, D.C.

Personal Communication

Van Zyll de Jong, C.D. 1990. National Museum of Natural Sciences, Zoology Division, Mammalogy Section. Ottawa. re: Number of wildlife species in Canada.

Data on File

Environment Canada, Canadian Wildlife Service, Migratory Birds and Wildlife Conservation Branch. re: Endangered species in Canada.

State of Wildlife

Books/Reports

Canadian Wildlife Service. 1990. (Draft.) Results Measurement Report. Environment Canada. Ottawa.

Clarke, H.A., C.D.A. Rubec, M.R. McKechnie, and J.D. McCuaig. 1989. Wetland conservation in Canada. In: Marchand, M., and H.A. Udo de Haes (eds.). The People's Role in Wetland Management. Proceedings of the International Conference. Leiden, The Netherlands.

Environment Canada. 1986. Wetlands in Canada: A Valuable Resource. Lands Directorate Fact Sheet 86-4. Lands Directorate. Ottawa.

Hyslop, C. 1990. (Draft.) Wildlife and habitat. In: Government of Canada. State of the Environment Report for Canada. Ottawa.

Landres, P.B., J. Verner, and J.W. Thomas. 1988. Ecological uses of vertebrate indicator species: A critique. The Journal of the Society for Conservation Biology 2(4): 316–328.

United States Fish and Wildlife Service and Canadian Wildlife Service. 1989. North American Waterfowl Management Plan: Progress Report.

United States Fish and Wildlife Service and Canadian Wildlife Service. 1986. North American Waterfowl Management Plan.

Wildlife Habitat Canada. 1990. (Draft.) Wildlife habitat loss. In: Government of Canada. 1991 State of the Environment Report for Canada. Ottawa.

Data on File

Environment Canada, Canadian Wildlife Service, Migratory Birds and Wildlife Conservation Branch. re: Wildlife population levels.

LAND

Protected Areas

Books/Reports

World Commission on Environment and Development. 1987. Our Common Future. Oxford University Press. New York.

Personal Communication

Turner, T. 1990. Environment Canada, State of the Environment Reporting. Ottawa. re: Protected areas database.

Data on File

Environment Canada, State of the Environment Reporting, Ecological Applications Division. re: Amount of protected area.

Urbanization

Books/Reports

Environment Canada. 1989. Urbanization and the Sustainability of Canada's Prime Capability Agricultural Land. Fact Sheet. Canadian Wildlife Service, Sustainable Development Branch. Ottawa.

Neimanis, V.P. 1979. Canada's Cities and Their Surrounding Land Resource. Canada Land Inventory Report No. 15. Environment Canada, Lands Directorate. Ottawa.

Warren, C.L., A. Kerr, and A.M. Turner. 1989. Urbanization of Rural Land in Canada, 1981–86. SOE Fact Sheet No. 89-1. Environment Canada, State of the Environment Reporting. Ottawa.

Solid Waste Management

Books/Reports

Federation of Canadian Municipalities. 1990. Survey Report: Solid Waste Management in Canadian Municipalities. Ottawa.

Washington Analysis Corporation. Cited in: National waste strategies, compared. 1989. Waste Age 20(11):78–84.

Data on File

Environment Canada, Environmental Protection, Office of Waste Management, Waste Management Branch. re: Waste generation statistics for various countries.

Environment Canada, State of the Environment Reporting. re: Waste management data compiled from municipal sources.

NATURAL ECONOMIC RESOURCES

Forestry

Books/Reports

Forestry Canada. 1989. Selected Forestry Statistics, Canada 1988. Information Report E-X-41. Economics Branch. Ottawa.

Kuhnke, D.H. 1989. Silviculture Statistics for Canada: An 11 Year Summary. Information Report NOR-X-301. Forestry Canada, Northern Forestry Centre. Edmonton.

Personal Communication

Samson, R. 1990. Forestry Canada, Economics and Statistics Directorate. Ottawa. re: Pulp mill effluents and regeneration success.

Smyth, J. 1990. Forestry Canada, Economics and Statistics Directorate. Ottawa. re: Regeneration success.

Data on File

Forestry Canada. re: Forest resource data (FORSTATS) program: statistics on forest inventory and management.

Agriculture

Books/Reports

Agriculture Canada. 1990. (Draft.) Agriculture, environment and sustainability. In: Government of Canada. 1991 State of the Environment Report for Canada. Ottawa.

Council on Environmental Quality. 1989. Environmental Trends. United States Government Printing Office. Washington, D.C.

Dominion Bureau of Statistics. 1925. Agriculture. 1921 Census of Canada. Volume V. Ottawa.

Dominion Bureau of Statistics. 1936. Agriculture. 1931 Census of Canada. Volume VIII. Ottawa.

Dominion Bureau of Statistics. 1947. Agriculture—Part I. 1941 Census of Canada. Ottawa.

Dominion Bureau of Statistics. 1953. Agriculture—Part I. 1951 Census of Canada. Volume VI. Ottawa.

Dominion Bureau of Statistics. 1963. Agriculture—Canada. 1961 Census of Canada. Catalogue No. 96-530. Ottawa.

Dominion Bureau of Statistics. 1968. Agriculture—Canada. 1966 Census of Canada. Catalogue No. 96-601. Ottawa.

Spearin, M., and K. O'Connor. 1990. Canadian Fertilizer Consumption Shipments and Trade, 1988/89. Agriculture Canada, Farm Development Policy Directorate. Ottawa.

Statistics Canada. 1973. Agriculture—Canada. 1971 Census of Canada. Catalogue No. 96-701. Ottawa.

Statistics Canada. 1978. Agriculture—Canada. 1976 Census of Canada. Catalogue No. 96-800. Ottawa.

Statistics Canada. 1982. Agriculture—Canada. 1981 Census of Canada. Catalogue No. 96-901. Ottawa.

Statistics Canada. 1987. Agriculture—Canada. 1986 Census of Canada. Catalogue No. 96-102. Ottawa.

Statistics Canada. Fertilizer Trade. Catalogue No. 46-207. Cited in: Spearin, M., and K. O'Connor. 1990. Canadian Fertilizer Consumption, Shipments and Trade, 1988/89. Agriculture Canada, Farm Development Policy Directorate. Ottawa.

The Census Office. 1904. Natural Products. 1901 Census of Canada. Volume II. Ottawa.

The Census and Statistics Office. 1914. Agriculture. 1911 Census of Canada. Volume IV. Ottawa.

Personal Communication

Trant, D. 1990. Statistics Canada, Analytical Studies Branch. Ottawa. re: Changes in agricultural land use.

Fisheries

Books/Reports

Baldwin, N.S., R.W. Saalfeld, M.A. Ross, and H.J. Buettner. 1979. Commercial Fish Production in the Great Lakes, 1867–1977. Great Lakes Fishery Commission Technical Report No. 3. Ann Arbor, Michigan.

Colborn, T.E., A. Davidson, S. Green, R.A. Hodge, C.I. Jackson, and R. Liroff. 1990. Great Lakes, Great Legacy? The Conservation Foundation, Washington, D.C., and The Institute for Research on Public Policy, Ottawa.

Council on Environmental Quality. 1981. Environmental Trends. United States Government Printing Office. Washington, D.C.

Council on Environmental Quality. 1989. Environmental Trends. United States Government Printing Office. Washington, D.C.

Fisheries and Oceans Canada. 1984. Resource Prospects for Canada's Atlantic Fisheries, 1985–1990. Ottawa.

Fisheries and Oceans Canada. 1988. Resource Prospects for Canada's Atlantic Fisheries, 1989–1993. Ottawa.

Fisheries and Oceans Canada. 1990. (Draft.) Fisheries. In: Government of Canada. 1991 State of the Environment Report for Canada. Ottawa.

Great Lakes Water Quality Board. 1987. Report on the Great Lakes Water Quality. Toledo, Ohio.

International Joint Commission. 1990. Fifth Biennial Report on Great Lakes Water Quality, Part II. Windsor.

Kirby, M.J.L. 1982. Naviguer dans la tourmente—Une nouvelle politique pour les pêches de l'Atlantique. Ministère des Pêches et Océans. Ottawa.

Pearse, P.H. 1982. Turning the Tide—A New Policy for Canada's Pacific Fisheries. Fisheries and Oceans Canada. Vancouver.

Pearse, P.H. 1988. Rising to the Challenge: A New Policy for Canada's Freshwater Fisheries. Canadian Wildlife Federation. Ottawa.

Pinhorn, A.T., and R.G. Halliday. 1990. Canadian versus international regulation of Northwest Atlantic fisheries: Management practices, fishery yields and resource trends, 1960–1986. North American Journal of Fisheries Management 10(2): 144–153.

Stocker, M., and B.M. Leaman. 1990. Effects of extended jurisdiction on management and conservation of Canada's Pacific coast fisheries. North American Journal of Fisheries Management 10(2): 154–174.

World Resources Institute. 1988. World Resources 1988–89. Basic Books, Inc. New York.

World Resources Institute. 1990. World Resources 1990–91. Oxford University Press. New York.

Data on File

Fisheries and Oceans Canada, Bayfield Institute, and Ontario Ministry of Natural Resources. re: Commercial freshwater fish catches.

Fisheries and Oceans Canada, Biological Sciences Directorate. re: Commercial marine fish catches.

Water Use

Books/Reports

Bird, P.M., and D.J. Rapport. 1986. State of the Environment Report for Canada. Environment Canada. Ottawa.

National Utility Services International Water Price Survey. 1989. Cited in: Who pays for water? World Water (London) 12(9): 30–31.

Organisation for Economic Co-operation and Development. 1990. (Draft.) The State of the Environment, 1991. Paris.

Pearse, P.H., F. Bertrand, and J. MacLaren. 1985. Currents of Change: Final Report. Inquiry on Federal Water Policy. Ottawa.

Statistics Canada. 1986. Human Activity and the Environment: A Statistical Compendium. Statistics Canada, Analytical Studies Branch. Ottawa.

Tate, D.M. 1990. Water Demand Management in Canada: A State of the Art Review. Social Science Series No. 23. Environment Canada, Inland Waters Directorate. Ottawa.

Data on File

Environment Canada, Inland Waters Directorate, Water Planning and Management Branch. re: Industrial water use database (INUDAT).

Environment Canada, Inland Waters Directorate, Water Planning and Management Branch. re: Municipal water use database (MUD).

Statistics Canada, Analytical Studies Branch. re: Gross Domestic Product data.

Energy

Books/Reports

Council on Environmental Quality. 1989. Environmental Trends. United States Government Printing Office. Washington, D.C.

Energy, Mines and Resources Canada. 1988. Energy and Canadians into the 21st Century: A Report on the Energy Options Process. Supply and Services Canada, Catalogue No. M27-89/1988-1. Ottawa.

International Energy Agency. 1988. Energy Policies and Programmes of IEA Countries: 1988 Review. Organisation for Economic Co-operation and Development/International Energy Agency. Paris.

Marbek Resource Consultants. 1990. Rationale and Preliminary Family of National Indicators for Sustainable Energy Production and Use. Prepared for the National Round Table on Environment and Economy.

Organisation for Economic Co-operation and Development. 1989. Environmental Data Compendium 1989. Paris.

Personal Communication

Coombs, A. 1990. Energy, Mines and Resources Canada, Economic and Fiscal Analysis Branch, Energy and Fiscal Analysis Division. Ottawa. re: Energy data interpretations.

Data on File

Energy, Mines and Resources Canada, Economic and Fiscal Analysis Branch, Energy and Fiscal Analysis Division. re: International Energy Agency database.

Annex 2

Framework Matrix

Framework Matrix for Developing Environmental Indicators

Category	*Types of indicators*		
	Condition (Exposure/Response)	**Human activity Stresses**	**Management Responses**
ENVIRONMENT COMPONENT/ ECOSYSTEM STATE			
ATMOSPHERE • Climate change • Stratospheric ozone depletion • Acid rain • Air quality			
WATER – FRESHWATER QUALITY • Surface water • Groundwater – MARINE QUALITY			
BIOTA (LIVING ORGANISMS) • Biological diversity • Wildlife			
LAND • Protected natural areas • Rural land conversion • Heritage sites			
ENVIRONMENT-RELATED HUMAN HEALTH			
DRINKING WATER			
RECREATIONAL WATER			
AIR QUALITY • Outdoor • Indoor			
TOXIC RESIDUES IN FOOD			
RADIATION EXPOSURE			
WASTE MANAGEMENT • Solid • Hazardous			
NATURAL ECONOMIC RESOURCES			
FORESTRY			
AGRICULTURE			
FISHERIES			
WATER USE			
ENERGY			

Elements of the matrix

Environmental components: atmosphere, water, biota (living organisms), and land. Gauging the health of ecosystems requires a set of chemical, physical, and biological indicators that measure environmental quality. For example: ambient concentrations of various pollutants (including SO_2 and NO_x) are chemical indicators of acid rain. Biological indicators (for example, birds or fish near the top of the food chain) can be used as measures of the state of the ecosystem.

Environment-related human health: it is necessary to have information on links between environmental quality and the potential risks to an individual's health. This includes indicators for water quality (both drinking and recreational use); urban air quality; food contamination; and waste management.

Natural economic resources: forests, agriculture, fisheries, water, and energy. Changes in the quality, quantity, and use of such resources, as measured by indicators, can tell us whether we are managing them in a manner that sustains them and the environment as a whole.

Measures of **condition** are those that refer to the quality and quantity of an environmental component or natural resource. They include the various exposures or responses (alterations/changes) of the environment to human activities.

Measures of **human activities or stress** refer to emissions and discharges, restructuring, or consumption of environmental resources that result from human activity.

Measures of **management responses** refer to the actions, policies, and programs undertaken to respond to stresses on the state of the environment or one of its components.